SCIENTIFIC AMERICAN

No. 655 SUPPLEMENT

Scientific American Supplement, Vol. XXVI., No. 655. | NEW YORK, JULY 21, 1888. | Scientific American Supplement, $5 a year.
Scientific American, established 1845. | | Scientific American and Supplement, $7 a year.

THE MOST POWERFUL ELECTRIC LIGHT IN THE WORLD.

At the southernmost point of the Isle of Wight, upon a plateau of rock some 80 ft. above the sea level, stands St. Catherine's Lighthouse, one of the most important links in the splendid chain of lights surrounding this dangerous coast. Though devoid of any pretension to architectural beauty—being, indeed, a squat and angular structure, as different from the flowing and graceful outlines of the Eddystone or the Bell Rock as well may be—yet it may be safely asserted that the sight of the Parthenon itself was never half so grateful to the most devoted art worshiper as is the stumpy pillar on St. Catherine's Point to the homeward bound mariner, who, wearily beating up channel in the teeth of a strong gale, and uncertain of his position, "picks up" afar off the electric flash, and literally "goes on his way rejoicing."

The beautiful southern coast of the Isle of Wight, with its balmy air—the veritable breath of life to the consumptive invalid—is yet a cruel and treacherous shore, exacting year by year, with a strange and pitiless accuracy, its tale of seamen's lives. For at certain seasons of the year a dense and impenetrable mist arises, wherein lights and landmarks are alike invisible; while, without a breath of wind to fill his sails, and all unconscious of the danger, the hapless navigator is silently drifting, borne along on the rapid inshore current toward the jagged and cruel rocks which everywhere surround this fatal coast. At such time the voice of the siren is heard, not, as of old, in soft music, luring mariners to their destruction, but a warning note, a harsh and dissonant yell, as of an angry beast disappointed of its prey, the voice of the fog horn on St. Catherine's Point proclaiming danger.

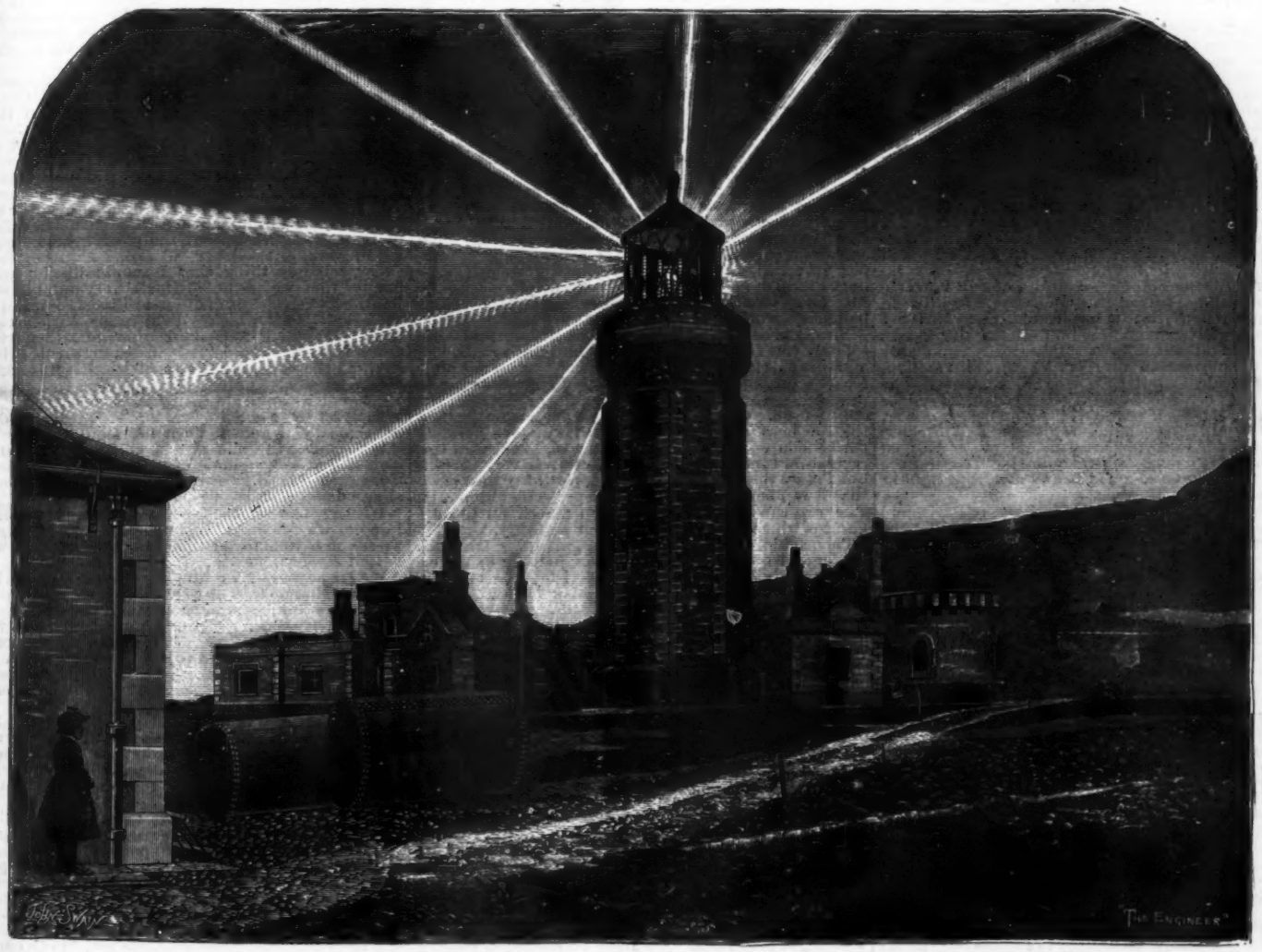
From very early times the necessity for a beacon at this spot has been recognized, for we read that in the fourteenth century a good knight built a chantry on the lofty summit of St. Catherine's Downs, and provided an annual sum for the maintenance of a priest "who should chant masses and maintain a burning light at night for the safety of mariners." This pious endowment was swept away at the dissolution of the minor religious houses, and the light extinguished, not to be rekindled until the year 1785, when the Trinity House was moved to establish a lighthouse on the Down; but it was soon found that the light was practically useless on account of the fogs in which it was frequently enveloped.

The erection of the present structure at a much lower elevation was commenced in the first year of her present Majesty's reign, and the light was exhibited for the first time on March 25, 1840. The lantern was, however, still found to be above the fog line, and a few years later the height of the tower was reduced by some forty feet, with a marked improvement in the illumination, the light now standing about 134 ft. above sea level at high water. Up to the beginning of the month of May, the apparatus consisted of a lamp constructed to burn mineral oil, having six concentric wicks, with an aggregate power of 740 candles, the light being refracted by a system of fixed dioptric lenses into a steady beam extending round about two-thirds of a circle, forming what is officially known as a "fixed oil light of the first class."

But this in its turn was destined to give place to a new illuminant; and in a "notice to mariners," dated nearly a year back, the corporation of the Trinity House were enabled to state that on and after Tuesday, the 1st of May, 1888, an alteration in the light and fog signal at St. Catherine's Point would be made, namely: "An electric light showing one flash of about five seconds' duration, every half minute, will be exhibited, and the fog signal will be changed to two blasts—high, low—in quick succession every minute."

By the courtesy of the Trinity House we were permitted to be present at the official inauguration of the new light, which, in accordance with the notice published so long beforehand, was duly displayed for the first time on the evening of May day. The effect—to a stranger—was most startling. As the twilight deepened, sixteen separate and sharply defined radial beams of light, likes the spokes of a gigantic cart wheel, were seen to be steadily traveling round the horizon. Far as the eye could reach, the electric rays slowly swept through the darkening space before us. Now and again a startled bird would flash through the beam, looking like a speck of fire; while to turn from the sublime to the ridiculous, the cattle upon St. Catherine's Down in wild alarm were scampering about, with tails high in air, pursued by brilliant patches of light, as the quickly succeeding rays impinged upon the surface of the sloping Down.

We strolled out to this spot, about a mile distant from the lighthouse—one of the most extraordinary walks it was ever our lot to undertake. The night was pitch dark, and the ground broken and irregular. High above our heads revolved continually the illuminated "spokes," but they shed no light upon our path, and it was only by the help of the white bowlder stones, which at intervals mark the coastguardsman's track, that we were able to pick our steps toward the spot where higher up on the Down broad patches of white light were rushing over the surface at full speed.



SAINT CATHERINE'S POINT LIGHTHOUSE—THE MOST POWERFUL LIGHT IN THE WORLD.

Here we came in for the full benefit of what the Trinity House prosaically terms "one flash of about five seconds' duration every half minute." And we could see to pick up a pin out of the grass. Then would come an interval of intense darkness, and then—for we were right in the focus of the apparatus—suddenly a blaze from the lens a mile off like the sun at noonday, and—darkness again. It was trying to the unaccustomed eye, to say the least of it. We made the best of our way back to the lighthouse, where we were permitted to inspect the apparatus. The lower story of St. Catherine's Lighthouse, or the hall, as it may be termed, contains one very singular object, namely, a white marble plaque, let into the pavement, having a black spot in the center, while nearly over the speck, but not quite, hangs, by a long wire from the ceiling, a heavy pointed weight or plumb bob. Landslips are not entirely unknown in the locality, and shortly before the tower was lowered it was found to have moved some three inches out of the perpendicular. To give timely warning of any further movement this apparatus was put up some twelve years ago, since which time the deflection has not been more than a quarter of an inch; but a meadow, which formerly stood between the tower and the sea, and upon which the keeper had the privilege of grazing a cow, has completely disappeared.

Up a steep winding stair, a minute later we emerge from the semi-darkness into the bewildering light of the lantern room. Being politely offered a pair of black spectacles, we proceed a few feet higher up an iron ladder to a small gallery surrounding the slowly revolving polygonal structure of glass by which the light is caught up from the electric lamp within and refracted into the sixteen radial beams which form the distinguishing feature of this latest achievement of optical science by that eminent firm of lighthouse engineers, Messrs. Chance Brothers, of Birmingham. Through two thicknesses of darkened glass we venture a momentary peep at the central source of light itself —the tiny point, no bigger than a marble—where, with a loud hissing sound, a fierce combustion, and the light of 60,000 candles, the electric arc itself bridges the ½ in. or so of interval which separates the incandescent carbon points. Some idea of the power of this light will be conveyed to the reader when we say that the carbon pencils employed in the electric arc lamps commonly used for street lighting are about ⅜ in. in thickness, while those at which we are now painfully gazing have a diameter of 60 mm., or nearly 2⅜ in.

The lamp is of the modified Serrin-Berjot type, and the carbons, which are controlled by a duplex arrangement of spring and current, are not circular in section, but fluted, a valuable improvement introduced by Sir James Douglass, whereby the centrality of the arc is greatly promoted, the carbons are kept cooler, and a better supply of air to the lamp afforded. The sixteen-paneled dioptric apparatus is rotated, not by clockwork, as usual, but by a tiny vertical engine worked by compressed air from below. As the time of rotation is of the utmost importance, a most ingenious regulator or governor is applied to the little engine, which controls the speed by the automatic application of a brake should the motion become too rapid. But we must take our leave of this most interesting apparatus, and descend to the basement, where the steam engines, dynamos, and air compressors are at work.

Entering the engine room, a handsome building to the right of the tower, we see before us a row of three compound engines and boilers, each of 12 nominal horse power, but capable, as we are informed, of working up to 48 horse power should occasion require. These highly finished engines have been made for the Trinity House by Messrs. Robey & Co., of Lincoln, and embody the latest improvements of that celebrated firm of engineers. The fuel used is gas coke, the residue from the manufacture of coal gas, coal being thus utilized a second time in the production of an illuminant. All the three engines were in steam at the time of our visit, although only one was actually in motion, engaged in driving one of the large dynamos which generate the electric current. The ease and smoothness with which this Robey engine was working was really remarkable—when running at 173 revolutions per minute scarcely a sound was perceptible in the engine room. Ready for instant use, with fire banked up and steam at 150 lb. pressure, the second engine stood attached to a duplicate dynamo, only needing the movement of a lever to start into motion, in case of accident to the first set of machinery. The primary duty of the third engine is to compress air for the siren or fog horn. Air compressors are, however, attached to all three engines for use in cases of emergency, and huge reservoirs are constantly kept charged with air at 900 lb. pressure per square inch, so that the warning note can be sounded at any moment, night or day, when necessity arises.

The two dynamos are by De Meritens, of Paris, and if both worked in conjunction, it is computed that the concentrated light from the lantern would equal six millions of candles. The induction arrangement of each machine consists of sixty permanent magnets, and each magnet is made up of eight steel plates. The armature, 2 ft. 6 in. in diameter, is composed of five rings with twenty-four bobbins in each, arranged in groups of four in tension and six in quantity.

Throughout the installation everything is duplicated, and sometimes triplicated, to guard against the possibility of the extinction of the light even for a moment; and the order, regularity, and method by which the duties of each man and each machine upon the establishment are allotted and fulfilled is exactly what one would expect from the Trinity Board, whose motto seems to be, "Without haste, without delay, and the best of everything."

The whole of the new works have been devised and originated by Sir James N. Douglass, the engineer in chief to the Trinity House, and carried out under the immediate superintendence of his assistants, Mr. Ayres and Mr. Matthews, while the completed arrangements have been put under the charge of Mr. H. C. Millet—late engineer, R. N.—who for the last seventeen years has had similar charge of the electric lighthouse at Souter Point, on the Durham coast. In concluding this notice it is our pleasant duty to express our thanks to the Trinity House for the opportunity of being present at the official trial of the most powerful electric light in the world at St. Catherine's Lighthouse, on the 1st of May, 1888.—*The Engineer.*

PRACTICAL APPLICATIONS OF ELECTRIC WELDING.*

By O. K. STEWART.

THE history of electric welding extends over a much longer period of time than is generally supposed. Some eleven years ago, Prof. Elihu Thomson, who then held the chair of Chemistry and Mechanics at the Philadelphia Central High School, was delivering a course of lectures before the Franklin Institute of that city, and among other experiments by which he intended to prove the substantially identical nature of electrical energy under any and all circumstances, he reversed an ordinary Ruhmkorf induction coil, showing thereby the difference of potential between the current in the primary and that in the secondary of the coil. In performing this experiment he brought the terminals of the coarse secondary winding of the coil into contact, and was surprised to notice that a high degree of temperature was reached instantaneously at the point of contact, in fact, such a high degree of heat that the ends were stuck quite firmly together, the copper wire being actually melted, so that it required considerable force to separate them. Instantly the thought flashed through his brain, electric welding

Professor Thomson was, however, very busily engaged in teaching and lecturing, and in developing the Thomson-Houston system of electric lighting for the next five or six years, and it was not until, in the regular course of manufacturing electric lighting apparatus, it became an imperative necessity to discover some means of having more perfect joints in copper wire than could then be obtained that his mind reverted again to the old experiment at the Franklin Institute, and electric welding became an assured art.

I should like further to call your attention to the fact that the discovery was made several years prior to the building of a welding machine. Several years ago, I do not remember the exact date, the necessity for welding the ends of copper wires became so imperative that Professor Thomson designed and built a small machine with which to weld fine wires. The experiments with this apparatus were so very successful that the inventor decided to build larger and better apparatus and experiment further with a view to welding, if possible, much larger pieces of metal. These experiments were also successful, and the invention has been much further developed in the past year or two than the general public can have any possible idea of.

The theory underlying or the principle involved in the Thomson process of electric welding is very simple, as indeed is most of the apparatus also. The Thomson process of electric welding consists simply in forcing through the pieces of metal to be welded currents of such large volume that these pieces can carry them without heating. Now, when the pieces are placed in abutment, the point of greatest resistance, as you all know, is where they contact with each other, and it is of course at this point that the heat is first generated. The instant heat is generated at the point of contact, the resistance at that place enormously increases and a consequent more rapid development of heat is the immediate result. The metals are consequently raised to a high welding temperature in a very remarkably short space of time, and upon a slight pressure being applied to force the pieces together, a perfect welding is effected.

The field that is open for the process of electric welding is surprisingly vast, and of course no one can tell where it will lead to. I think the most important reason why electric welding is taking its place so rapidly—no, I will not say most important, but one of the most important reasons why electric welding is taking an important place so rapidly—is that the heat generated by the current is the only absolutely pure heat known in the world. The blacksmith, when welding with either a gas furnace or a coal fire, is constantly running the risk not only of burning his metal, but of introducing into it foreign matter in the form of gases which are very deleterious to the substances of either iron or steel, which are the principal metals worked by blacksmiths.

Now, the heat generated by the electric current is absolutely free from all foreign and harmful substances, and it is this fact, I think, which very largely accounts for the rapid advance of electric welding, so far as practical work is concerned. Of course, this is not the only reason. One very important reason is the fact that the heat effected by the current is under absolutely perfect control. Now, I do not mean to say that this regulation is nearly perfect, or that it is very perfect, but I state that it is absolutely perfect, for the reason that it can be made entirely and perfectly automatic. The heat can be begun, and a stop placed on the apparatus which will control the heat perfectly.

Then again, welding by the Thomson process is a much neater and quicker operation than welding by the ordinary method of forge or furnace. I might also say in this connection that no skilled labor is necessary to operate an electric welding apparatus. I have in my mind now one young man who came to us not knowing anything of the conditions under which different metals should be welded, and who in a very short time has became so expert in handling these machines that he can now, on the first trial, make perfect welds in any of the ordinary metals and in almost all varieties of steel, including, although I say it with some reservation, even Mushet steel and manganese steel.

As I have already stated, the field for electric welding is so very broad that I have been really much embarrassed in endeavoring to present the most interesting portions of it to you this evening. There are hundreds of applications of the process, and under the circumstances I do not think I can do better than simply cite one or two instances or examples of very small work, and then some of larger work. We are not limited of course in our work by the size of the pieces to be welded. We can weld the finest wires and the heaviest pieces. As an example of quite small, though not the smallest, work, I might mention the welding of gold rings. We have succeeded in welding gold rings. I want to call your attention to the fact that I say we *have* succeeded, you understand, *have*. It is no longer a matter of experiment, but the welding of gold rings by our process is an assured success. Now, what does this mean? It means, first, that we can make a better joint than is now made, doing away entirely with soldering, and in its place making a continuous gold ring; secondly, it means that the work is accomplished in about one-fifth of the time that it now takes to make a decent joint; and it means, lastly, that soldering material is saved, that an enormous wasting of heat is done away with, and that the dangers of burning gas are entirely obviated.

As an example of somewhat larger work, I might mention the welding of axes. There is, not very far from Boston, a manufacturing establishment which turns out about three thousand axes a day. Their ax is made of a body of ordinary wrought iron, to which is welded an edge or face of fine tool steel, tempered and toughened. Their pieces of metal, before welding, have to be prepared somewhat in this manner. That is, a groove is cut in the body of the ax, while a taper is cut on the face or blade, the latter being set into the former and the pieces welded in this position. (Blackboard illustrations.)

Now, in electric welding we do away entirely with this preparation, and I am very glad to say that without very much experimenting we have been able to entirely convert the engineer of this company to electric welding. He is now a firm believer that electric welding is the thing so far as the ax business is concerned.

As an example of much larger work, I might mention the welding of pedestals and locomotive frames. This is an entirely different class of work. The pieces have to be carefully prepared like this (blackboard illustrations), a raised portion being left on the base or edge of the frame, and a taper groove being cut in the pedestal so that it may fit down over the raised portion referred to.

Some months ago I had the pleasure of being in Philadelphia, and while there of walking through the Baldwin Locomotive Works. This establishment is turning out fourteen locomotives a week. Now, what does this mean for electric welding? In the first place, on these engines there are some five or six copper rings, the wire composing which is of small diameter. The joints in these rings are at present made with a blow-pipe flame, and it takes an expert some four or five minutes to make a single one. We can make them in as many seconds. There are also on each one of these locomotives at least one hundred and fifty joints in iron, from a half inch area of section to several inches area. Now, it takes anywhere from four to fifteen minutes to make these joints by the ordinary process, and welding, you must remember, has been reduced to a very economical and accurate art in this establishment, but nevertheless we can do the work in at least one-fifth of the time which they now occupy. There are on each one of these locomotives four frames, each frame having on it at least two, sometimes three, four, and five pedestals. We will suppose that the average is three pedestals per frame. That makes twelve pedestals to the locomotive. To prepare the ends of the pedestals and the taper on the base of the frame takes some forty minutes. They have to be heated and hammered into shape while hot. After they are prepared in this manner (blackboard illustrations), they have to be reheated to a welding temperature, placed under a steam hammer and welded, this last operation requiring some thirty or forty minutes. You can easily see what this means. We allow twelve joints to each locomotive, and this makes one hundred and sixty-eight pedestal welds a week—one hundred and sixty-eight welds, understand me, which require at least one hour's time each.

In talking the matter over with Mr. Converse, who is the general manager of the company, I think we came to the conclusion that we could "beat this all hollow," the only question in the mind of Mr. Converse being whether the weld would be as perfect as at present. You will see that we would do away entirely with the preparation of the pieces, making a butt weld of the pedestal to the bit or expansion on the base.

There are, of course, a large number of other applications, but I think that these three should be sufficient to indicate at least what the possibilities of electric welding are.

There is one thing that I should like to mention finally, that we are able to make very durable, strong joints between metals of different kinds. For instance, these specimens which I hold in my hand consist of brass and copper welded together, and then twisted around twice. The joint held through this twisting, showing the strength. You will see that it is not even cracked.

What do we expect in the future for electric welding? We expect to be able to weld boiler plates. We do not say that we are able to do it now, but we have been thinking over the matter and experimenting, and we believe that this welding of boiler plates together is a thing of the not distant future. The same may be said of any metal plates.

We expect also to be able to weld tubes in the length. I do not wish to be misunderstood. I do not say that we are now able to do this, but I do say that we believe it can be done.

We are at present working upon apparatus of a light, movable character, which, without mechanical power, we believe will be powerful enough to weld line wire, such as telephone, telegraph, and electric light and power wires on the line. The apparatus can be put into a wagon and carried to any desirable point. The current obtained from storage batteries forms a portion of the apparatus, and the welding is effected on the line.

We expect also to weld lead pipe in the same manner, so that any plumber can have a welding apparatus with which he can make one continuous lead pipe in mending and in building, doing away entirely with "wipe joints," and the expense attendant thereon.

With an absolutely pure heat, with absolutely perfect means of regulation, with the heating constantly before the eyes of the operator, with a neatness to which ordinary methods cannot at all be compared, with an increased economy of, in all ordinary cases, at least 300 per cent., with absolute safety of handling apparatus—with all these advantages, I do not see why electric welding should not rapidly rise to the dignity of a most important and valuable art. I can only say in conclusion that I shall be glad to answer any questions that I can answer and which may be asked.

* An address recently delivered before the Boston Electric Club.

IMPROVED ALTERNATE CURRENT DYNAMO.

THE alternate current dynamo which we illustrate opposite is the invention of Mr. W. M. Mordey, and is being brought out by the Anglo-American Brush Electric Light Corporation, London. It is a wide departure from the usual form of alternate current machine, and presents several features of great interest. The armature coils are stationary, while the field magnets revolve. This, of itself, is not new, but the idea is carried out in this machine in a perfectly original manner. The coils are quite thin, and stand between the poles of a revolving magnet, the space separating the poles being very short, and consequently forming a very intense field, which is almost filled with the coils. All the magnet poles on one side of the coils are of one sign (say north), and all the poles on the other side of the opposite sign (south). This is contrary to the usual practice, in which north and south poles occur alternately. It follows from this arrangement that the polarity in the coils is not reversed as the magnets revolve, but instead it rises from zero to the maximum, and then falls to zero again, and so on. The magnetization of the coils is always of the same character; it merely varies in intensity. This variation is as great as in the old machines, because the field is so much stronger. Formerly, when north and south poles occurred in the magnet, side by side,

there was a great amount of sideways leakage between them, but with the present arrangement this is entirely avoided, and the lines of force pass directly through the armature coils. The electrical advantages of this arrangement are also attended by a great simplification of the mechanical details.

Referring to the engravings, it will be seen (Figs. 2, 6, and 7) that the armature coils are formed separately of copper ribbon, which is only $\frac{1}{16}$ in. wide, wound on non-conducting cores. Each core is bolted at the broad end between two brackets, and the ends of the conductors brought out through porcelain insulators. These brackets are then bolted to a gun metal supporting ring (Fig. 2) formed in halves, so that they can be removed without dismounting the machine. The coils stand in the narrow space between the poles of the field magnet (Fig. 3). This magnet is formed of a central coil wound on a core with polar extensions of the form shown in the engraving. The current from the exciter (Fig. 4), which is drawn to scale, is conducted to the magnet coil by a pair of rubbing rings on the shaft. When in the machine, the magnet is provided with covers (Fig. 1) which prevent needless churning of the air. Next to the contact rings are the collars of a thrust bearing by which the magnet is adjusted exactly with relation to the armature coils. The diameter of the revolving magnet is 2 ft. 11 in. The weight of the complete machine is about 41 cwt., of which nearly one-half is made up of bed plate and parts which have no electrical function.

Fig. 5 is a small adjustable resistance, which is all that is required for regulating. The dynamo is in fact very nearly self-regulating in itself, as is shown by Fig. 8, giving the characteristic of the machine throughout a range of 37,000 watts. From this curve it is clear that practically the whole of the load for (say) 600 lamps might safely be turned off without danger to any remaining lamps, and that probably a large proportion of the load, certainly 50 per cent., could be turned off without attracting notice on the rest of the circuit. It is, therefore, not considered desirable, except under special circumstances, to provide other than a simple hand regulation for controlling the potential difference.

By this arrangement of the armature coils it is easy to obtain various combinations if desired. This circumstance is made use of for simplifying the measurement of the potential. Instead of taking the reading across the terminals, which would necessitate the use of an electrometer or a very high resistance voltmeter, an ordinary voltmeter indicating to 100 or 150 volts is placed across one of the coils.

We understand that this dynamo of 50 to 60 horse-power—the first of its type—was built directly from the first design without any preliminary experiment.—*Engineering.*

THE *Electric Review* thinks that Edison's scheme for electrical execution of criminals is the best so far presented. He proposes to manacle the wrists, with chain connections, place the black cap on the condemned, and at the proper time close the circuit. The shock passes through both arms, the heart, and the base of the brain, and death is instantaneous and painless. The plan does away with the paraphernalia of chairs, necklaces, helmets, sandals, and other complications hitherto proposed.

RULING GRADIENT.

By ELIOT HOLBROOK, S.B.

HOW well I remember, while yet struggling to master the contents of certain red-covered text books, that what then seemed a grand idea slowly settled itself into the seat of my understanding. I saw how, with one grand effort, the profile of a road was fixed; I saw how, when we had ascertained what grade was practicable over some range of hills, or perhaps across some deep valley, we had fixed the grades for perhaps one hundred miles on either side. For having determined the ruling gradient, we should use it wherever it was less expensive than another.

A few years later I was called upon to see what could be done to meet the constant demand for cheaper transportation; and transportation in all its details must be studied. I saw that the operating department was taking advantage of certain peculiarities of the profile, and doing what the locating engineer never dreamed of. From observations while riding on freight trains and while at the dispatcher's desk, I saw the trouble caused by a badly broken profile, and finally I saw that my idea of a ruling gradient was a delusion.

I saw that in building a road the problem to be solved was how, with a given amount to expend, to make a road which could be operated for less expense than any other that could be built for that amount; and if the amount to be expended was not fixed, to determine how much should be expended to give the best returns in operating profit.

The problem is complex. If lines are already built with which you must compete, they must be studied, that you may know what they are capable of doing, at present or in future.

It will be usually throwing away money to build a line more expensive to operate than your competitor, or even as expensive, for you will only get business at profitable rates when there is more business than your competitor can do. The relation of your line to water transportation should be carefully studied. The business of the cities, towns, and country along and adjacent to your line must be studied.

Business may be much heavier on some portions of a line than on others. This has great bearing on determining the profile. The business of a line may be accumulative in its heaviest direction; that is, if it runs through a larger wheat, coal, lumber, or ore region, it will pick up freight so that the amount arriving at one end may be several times as great as that leaving the other. On the other hand, the freight may be distributive in its heaviest direction, as the case of a road which brings coal and raw material from one end of its line to a manufacturing district, especially if the products of manufacturing largely go back in the direction from which the raw material comes, as in the case with most Eastern roads.

Likewise the traffic of a road may be either accumulative or distributive in the direction of its lightest traffic. We may have on a line of road any possible combination of these cases over the whole line or a part of it, and these conditions may change with the season.

If we consider only what has been said above, it will be seen that the relative importance of grades may depend largely upon their location and direction; so much so, that on a road that has only a limited number of empty cars to be taken to one end of the road and picks up loads returning, a grade of one hundred feet to the mile at one end against the direction of empty cars may not be as objectionable as a grade of ten feet to the mile against the direction of loaded cars at the other end.

Having made a careful estimate of the probable business of the proposed line in all its particulars for the present and future (when doing this, do not base your estimates in any way on the rates that the lines which are to be your competitors now get, but rather see what your competitors are capable of doing), you are prepared now to take up the study of physical features of the country through which the line is to go.

In studying the expenses of conducting transportation of a road, we will find for a given number of cars transported in each direction that some of the items of expenses are independent of the number of trains employed to transport this number of cars, while many items are very nearly proportionate to the number of trains, and a very few are increased by diminishing the number of trains.

Further, the experiences of numerous single track roads has shown that it is rather the number of trains that limits the capacity of the road, than the number of cars. To illustrate: A road over which trains of 60 cars can be drawn can handle 600 cars per day with nearly as great ease as 200 can be handled on a road that can only pull 20, provided the sidings are proportionately long; at the same time, scarcely more than one-third as many engines are required.

Our problem now is to see, with the means at our disposal, how to get a line over which we can get our traffic with the least possible expense; and as we have seen, this means, in general terms, with the least train mileage, or in other words, with the greatest average number of cars to the train. Every attempt should be made to locate the line so as to get the heavy grades where the tonnage is small. It will be found that it will often pay to spend large sums to avoid a short piece of heavy grade when there are long pieces of level track on either side. You will find if you can get twenty or more miles of low grade in a place, you can double your engines on the hills.

If your line obliges you to go from a certain point in a valley to a gap in a range, it will not usually be policy to lengthen the line to keep down the grade unless it is an extreme case, and the amount of curvature is not increased too much.

The least mechanical energy is expended by moving from the base to the summit in a straight line. For every 360 degrees of curvature, you have added work equivalent to raising the same eighteen feet; you also rapidly increase the cost of maintenance.

What may be called a double ruling gradient can often be worked advantageously; that is, a low grade used in as long pieces as possible, and then a grade where one-half as many cars can be pulled. This may be found in this way. Example: We find we can build from 30 to 40 miles with no grade greater than 40 feet to the mile, but must finally climb a range with a much steeper grade; what grade can I pull half as many cars as on the 40' grade?

The resistance caused by friction equals the resistance of gravity on a 16' grade. Therefore, total resistance of 40' grade equals resistance of gravity on 56' grade.

FIG. 1.

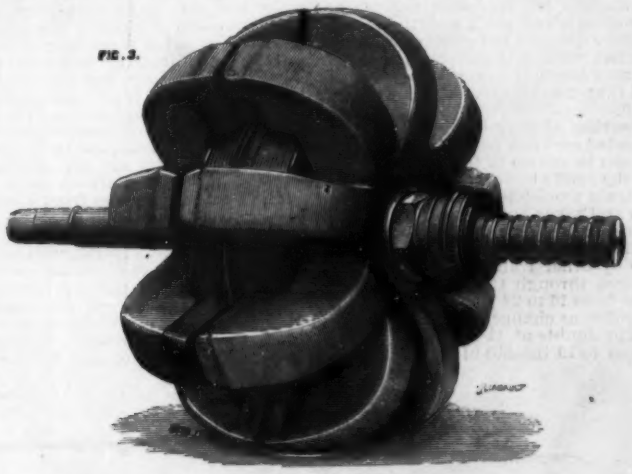


FIG. 3.

FIG. 5

FIG. 4.

FIG. 6

FIG. 7

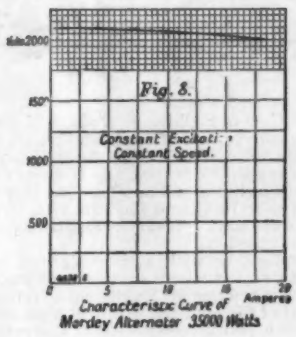


FIG. 2.

THE MORDEY ALTERNATE CURRENT DYNAMO.

We will estimate weight of engine and caboose at 10 per cent. of the train; therefore, with half the cars of the train we will have 10 per cent. plus 45 per cent., or 55 per cent. of the former weight. Therefore, the resistance may be increased in the ratio of 55 to 100, or $\frac{100}{55}$ of 56, equal 102. Deducting 16 for the resistance of friction of train, we have 88' as the double of 40'. The example may be reversed; that is, from the grade that it is necessary to use on the hill, you may want to use one in the level district where you can double the trains used on the hills.

In all questions of grade, the number of engines required in each case should be considered. If grades can be altered to save the service of one engine, you have $8,000 to expend in grading without increasing the total cost of your road and equipment, while you save the perpetual attendant expense of the engine, and probably save in maintenance of way expenses also.

There are many roads in operation which have gone on buying engines, when the money spent for these engines, expended in reducing some of the grades, would save the expense of operating and repairing those engines, and still larger expense as the business increased.

The introduction of couplings without free slack and with power brakes will remove the objection that has been raised to larger trains in the past. The tendency at present is decidedly for larger trains, and is opposed only by those who have never tried it.

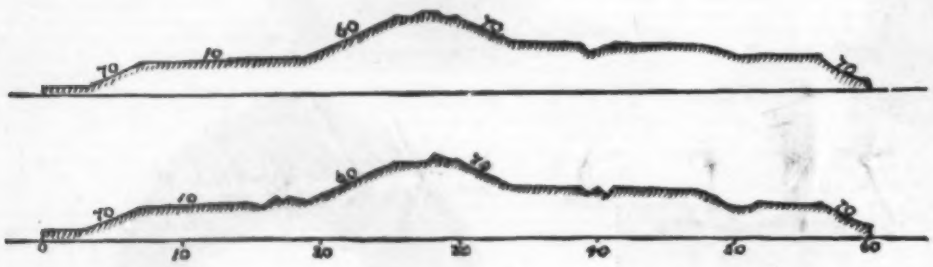
With an example of the application of ruling gradients as it has been used in the past, I will close.

The lower diagram is a representation of the profile of sixty miles of existing road, and the upper one is the same, slightly changed to facilitate traffic. The direction of lightest traffic is from 60 toward 0. A fair estimate will be that one-half the cars are empty between 60 and 40 and that two-thirds of the cars are empty between 40 and 0.

With the heaviest class of engines generally in use, twenty-five loaded cars can be drawn from 0 to 60, and fifty empties can be drawn in the other direction.

At present the traffic is worked in this way: An engine takes a train from 0 to 7, and returns and takes another train and takes both trains from 7 to 16, when it takes the original train again. One or two trains per day are set off at 30, and are taken away three or four cars at a time by other trains, as they can draw three or four cars more through the gaps at 40 and 50 than they can draw from 16 to 28.

With the profile as changed, the operation would be as follows: The double of the train drawn from 0 to 7 would be taken to 19 instead of 16, and would also be



taken from 26 to 60. This would require some trains to double, returning between 60 and 56, and between 34 and 30. Now let us suppose that the heaviest traffic is three hundred cars per day in each direction, and that the engines make one hundred miles per day. Let us see what some of the principal items in saving amount to, as at present:

12 trains each way are required between	0	and	7	equals	168	miles.
6	"	"	"	7	"	16	"	108	"
12	"	"	"	16	"	30	"	336	"
10	"	"	"	30	"	60	"	600	"
			Total,					1212	"

Profile Changed.

12 trains each way would be required between	0	and	7	equals	168	miles.
6	"	"	"	7	"	19	"	144	"
12	"	"	"	19	"	26	"	168	"
6	"	"	"	26	"	60	"	408	"
Add for 3 trains doubling,				60	"	56	"	13	"
" 2 "				34	"	30	"	8	"
Saving in train mileage, 304 miles.			Total,					906	"

The slight changes in the profile only reduces the mechanical energy required to move a given weight from 0 to 60 three per cent., and the less number of engines required to be moved takes two per cent. from the total work of moving the traffic; so we cannot say that we save much in fuel or repairs of engines, as the fewer engines are worked harder on the light grade, but we will save the expenses of three crews, or about $50 per day, besides some saving in maintenance of way and telegraph service. At the same time, the capacity of the road is increased.

Had the road originally been built on the changed profile, the increased cost would have all been confined to about four miles of grading, and would have been less than $100,000.

To the saving of $50 per day add the interest on the cost of three engines and the deterioration in value of the same, and we will find that saving in wages and motive power alone will reach twenty-five per cent. on the investment.

In the case of this piece of road, a short piece of the ruling gradient, less than a mile long, was used at miles 17, 18, 28, and 40, and one less than two miles long at 50, with what result we have seen. This is only one case of hundreds where roads are handicapped by engineers who have made no study of transportation matters.

When changing the short steep grades, it may often be done in a manner which will meet the wants of the case, and yet cost much less, to change the whole piece. For example: The total height of the point at 38 above the level on either side is forty-two feet, and in our case the engine is able to pull steadily twenty-five loads up this grade, and we want to pass them with fifty. This point being three miles from a station, the train can approach it at full speed when going toward 60. Now, since the engine can pull half the train up this grade, we may roughly say that the momentum can be expended on the other half, which would lift it from twenty to thirty feet; so that for half the distance we may let the grade remain, and change the upper part only to a grade over which a train can pull twice what it can on a 70 foot grade, or $\frac{70+16}{2} - 16$ equals 27.

If we go into the details of the calculation, it will be found that if the summit is lowered eight feet, the momentum acquired in moving from 26 will enable the engines to take the trains over without trouble.—*Technology Quarterly.*

THE PANAMA SHIP CANAL.

IN giving, to the best of our information, a just and correct account of this huge undertaking, we shall refrain from expressing any opinion with regard to its financial prospects, which concern a very large number of French shareholders, for whose sake we shall continue to hope that it may, at some future period, become a remunerative investment. How many years' labor, how many millions sterling of expenditure, it will yet cost, we do not pretend to guess. We are firmly convinced that the world in general, England and the British colonies in particular, will ultimately derive immense advantages from the execution of the work; and it is not unlikely that the further delay of a few years in its completion may prove rather beneficial to some part of the shipping and mercantile interests, by allowing them more time to prepare for a considerable shifting of maritime trade from other routes of ocean carriage and travel. On public grounds, it seems to us, there is no reason whatever for national jealousy of the attempt to open for European traffic this most direct way of communication with the coasts of the Pacific Ocean; as there was no reasonable ground, thirty years ago, for objecting to the canal by which ships of all nations, seven eighths of their tonnage British, now pass from the Mediterranean to the Red Sea and the Indian Ocean. It is obvious that the advantage to our fellow subjects in Australia and New Zealand, by superseding the tedious and perilous homeward voyage of sailing vessels round Cape Horn with the shortest possible line to Great Britain, will be of much commercial importance, as the freight charges and risks, especially of wool and wheat cargoes, must thereby be lessened. India will probably not be greatly affected by the new route of navigation; and it may be doubted whether our Chinese trade will alter its course. For the conveyance of mails and passengers to China and Japan, the Canadian Pacific Railway must certainly be more expeditious than any transit of steamships through the Isthmus of Panama. The Peninsular and Oriental route to India and Eastern Asia, however, should hold its own against every competitor proceeding in a western direction.

It would, therefore, be with a short-sighted view of our own interests, and it would show a captious, peevish, and unworthy temper, if Englishmen refused to join with the rest of the civilized world, at least with the rest of Europe, in a frank recognition of the extraordinary merits and services of M. Ferdinand De Lesseps, the successful projector and constructor of the Suez Canal, the founder of the Panama Canal Company, and hitherto its active director. The life and achievements of this truly "grand old man," this wonderful octogenarian, who has fought so many pacific and beneficent battles for purposes most useful to mankind, and whose brave spirit and genius for practical business are still unabated by venerable age, unexhausted by a multiplicity of toils, negotiations, and discussions, have frequently been a theme of admiring comment.

In the second volume of his autobiographical memoirs, "Recollections of Forty Years," recently noticed by us, he relates with simple and unassuming fidelity the circumstances attending his commencement of the present great work—one that he may hope either to finish in his lifetime, or to bequeath to competent successors, aided by the good will of his own countrymen, who are justly proud of such a man. It was in 1875, at the Paris International Congress, over which he presided, that the scheme of an interoceanic canal was revived, which had been conceived by the early Spanish conquerors of Central America in the sixteenth century, and on which many ingenious persons have written treatises—among them Prince Louis Napoleon, long before he became the Emperor Napoleon III. Two companies were formed, to send out preliminary exploring expeditions. One of these examined the Lake Nicaragua route, which Louis Napoleon had recommended; the other, led by the Hungarian General Turr, visited the isthmus, in the parts about Panama and Darien; and there were surveying parties of officers also from the United States occupied in a similar quest. M. De Lesseps, having collected all their reports, convened in May, 1879, a special congress of geographers, engineers, surveyors, merchants, sailors, ship owners, and others of all nations to the number of a hundred or more, who during a fortnight gave their continuous attention to this question. They were divided into five committees, appointed respectively to estimate the probable traffic of the canal, the rate of charges it would bear, and the consequent revenue, the nautical conditions of its working, the geographical route to be chosen, and the means and cost of construction. The comparative facilities of different proposed routes—those of Tehuantepec and Honduras, from the Gulf of Mexico, Nicaragua, Panama, San Blas, Darien, and the Atrato River of northwest South America—were minutely investigated. Some of these would require a number of locks, others would demand tunnels. The congress finally resolved, by seventy-eight votes against eight, twelve abstaining, that the canal at the sea level, without any locks, should be made from the Bay of Limon to the Bay of Panama; all the committees agreed in favor of this resolution. Other recommendations of the congress have been followed by the company which M. De Lesseps formed to execute the work, styled "La Compagnie Universelle du Canal Interoceanique de Panama."

In July, 1879, M. Ferdinand De Lesseps concluded an arrangement with M. Bonaparte Wyse and his associates for the purchase of a concession granted to the latter by the government of the Colombian Republic, for a canal across the Isthmus of Panama. On the 23d of that month, M. De Lesseps published his first prospectus, inviting subscriptions for 800,000 shares of 500f. each, giving a capital of £16,000,000. The shares were not taken up; but in November, 1880, a second prospectus was issued, for 600,000 shares; and upward of 1,200,000 shares were then applied for by 102,230 subscribers. The company was thus constituted, with a capital of £12,000,000, in 600,000 £20 shares which have been paid up in full; and the company has contracted six loans, mostly bearing three per cent. interest, but taken at large disconnt, the total amount of obligations, in 1887, being £53,901,100, which had produced in cash £29,909,348; the annual charge for interest, with that for the sinking fund, is £2,668,458. The total cost of the work, allowing 10 per cent. for contingencies, was estimated in 1880 at £33,748,000; but it is now calculated that £24,000,000 more will be required. The actual expenditure up to June 30, 1887, may be taken at £46,000,000.

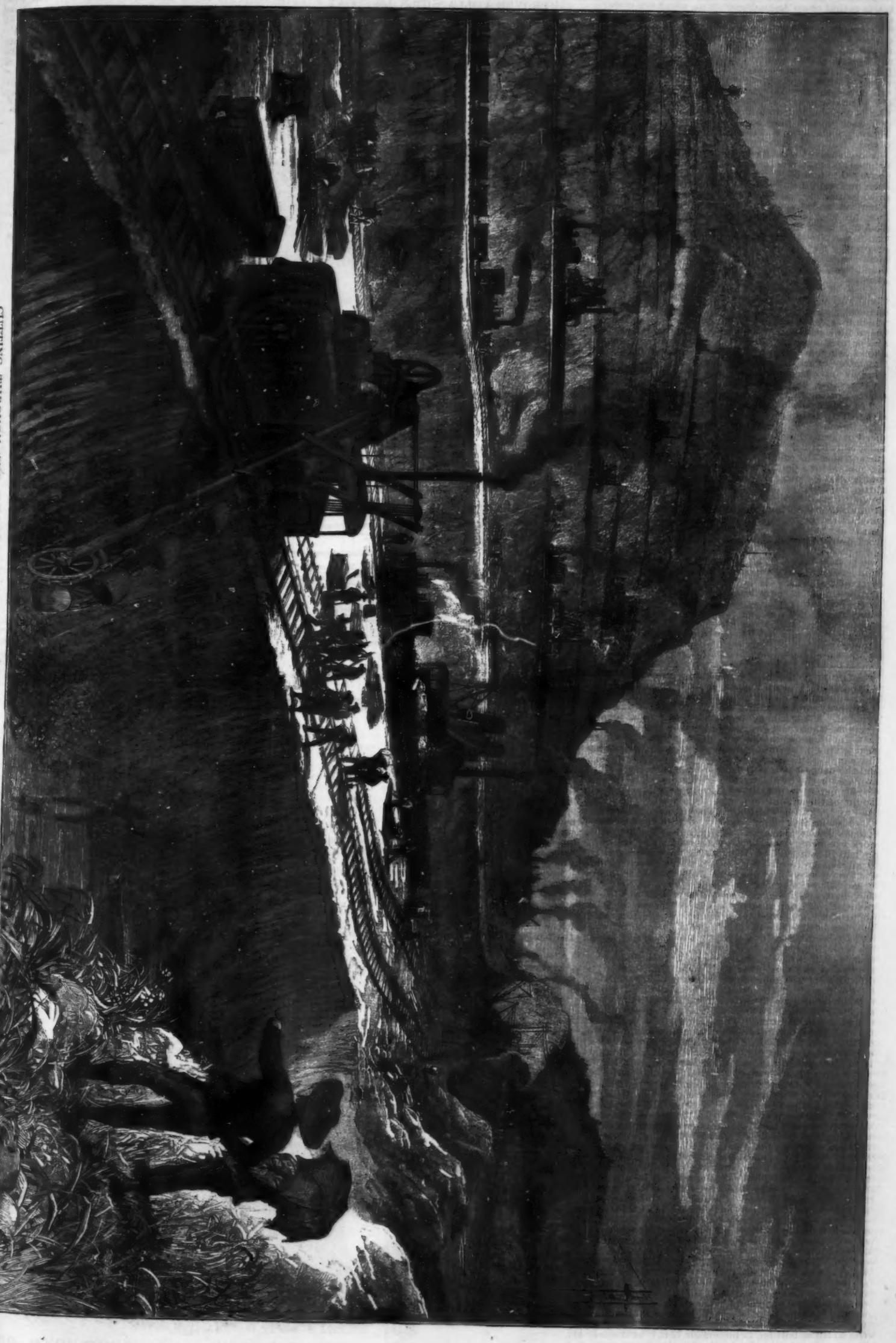
The total length of the canal, from the Bay of Limon, near Colon, on the Atlantic shore, to the Boca or mouth of the Rio Grande, in the Bay of Panama, on the Pacific coast, is scarcely forty-six miles. The difficulties in its construction occur mainly in dealing with the river Chagres, which is subject to high floods that would destroy the canal works, and in cutting through the range of hills, a portion of the Cordilleras that rise toward the Pacific side of Central and South America, constituting the backbone of the continent, and in some parts of the isthmus attaining a mountainous elevation. But the greatest height in the saddleback pass of these hills between the valleys of the Rio Grande and that of the Obispo, a highland tributary of the Chagres River, is 360 ft. above the sea level, at Culebra; while the height at Emperador is 200 ft. Instead of making ships ascend by a series of locks, as was proposed by some engineers, to the elevation of 120 ft., which would undoubtedly be practicable, it was decided to undertake cuttings all the way at the sea level. This was expected to involve the excavation and removal of seventy-two million cubic meters of earth (about ninety-five million cubic yards); but it is believed that a very much greater quantity of earth must be taken away, in order to give the sides of the cuttings, where they are of soft earth, a sufficient slope to prevent its being washed down into the canal by the tropical rains. To the 360 ft. above the sea level we must add 29 ft., the depth of the intended canal. A cutting, in any case, which must be nearly 390 ft. deep, in the Culebra section, for a length of two kilometers (a mile and a quarter), and 1,000 ft. wide at the top, is no trifling job; the Obispo and Emperador cuttings are likewise big pieces of work. This, however, is only a matter of toil, cost, and time. The most serious obstacle to the completion of the canal is the Chagres River. It is small and sluggish during the dry season, but becomes a torrent almost uncontrollable at the end of the wet season.

During the great flood of November, 1879, the railroad was covered with water nearly eighteen feet deep from Colon to Emperador, over thirty miles. Another such flood would in a few hours undo much of the work between Colon and Emperador. The plan for controlling the Chagres River is a very bold one; it is to divert its course from joining the Obispo, opposite Matachin, by the construction of an immense dam at Gamboa, about a mile long and 205 ft. above the level of the river at that point. This dam is to be 50 ft. wide, and protected by solid masonry. A large culvert through this dam will be provided with sluice gates, by means of which the flow of the river from the upper valley can be temporarily checked, and the water will thus be made to collect in the natural basin formed by the hills.

After the floods the water thus collected will be gradually, and it is believed quite safely, drained through the culvert. The construction of this dam will cost a larger sum of money than was at first thought; but it will utilize a large quantity of the earth and stone removed from the hill cuttings. The hill region has a total width of nearly nine miles, from Bas Obispo to Paraiso, with an average height of 147 ft. In the valley of the Obispo the surface is very irregular until Emperador is reached, at 200 ft. above sea level, and two and a quarter miles from Matachin. The line through this cutting has been laid out with curves of about one mile radius.

The port of entry of the canal at Colon, on the Atlantic coast, has been excavated at Fox River, where a temporary port has been established for the reception and storage of material. From this point, the canal, skirting the morass of Mindi, passes into the valley of the Chagres at Gatun, whence the line follows the valley to San Pablo, between the railway and the river on the left side, cutting the river at several points, and crossing the railway at San Pablo. Thence the line of the canal passes to Matachin, cutting many bends of the river *en route* and following generally the right bank, which is quitted at Matachin, where the canal enters the valley of the Obispo. The Matachin at low water is 44 ft. above the level of the sea. The average fall of the bed of the river is only 1 in 3,300, and the ground is marshy.

The excavation of different sections is intrusted to contractors paid by the cubic meter at rates varying from 1s. to about 6s., according to the nature of the soil, all plant being furnished by the company, who charge 6 per cent. on its cost. One of the largest con-



CUTTING THROUGH THE CULEBRA MOUNTAIN: GENERAL VIEW LOOKING WEST, TOWARDS PANAMA.

tracts is that of an Anglo-Dutch firm, who have undertaken the removal of three million cubic meters from the Culebra cut within two years, at 1·76 dols. Colombian currency (about 6s.) per cubic meter. The machinery is principally French, Belgian, and American, and consists of great steam dredges, compressed air perforators, hydraulic machinery steam shovels, and derricks. The canal dredging between Colon and Gatun was undertaken by Messrs. Hulme, Slaven & Co., at 1f. 50c. per cubic meter. From the hill cuttings, the rubbish is removed in "dumping cars," running on rails, of French and Belgian construction, the larger holding six cubic meters and the smaller half a cubic meter of soil.

About twelve thousand laborers, mostly West Indian negroes and mulattoes, are employed in all. They are conveyed to and fro by the railway. The stations have been built on hills in proximity to the works, and comprise houses for the engineers, the foremen, and the American and European workmen, and ranchos or huts for the blacks. These ranchos give shelter to from four to six hundred workmen. The houses contain from thirty to fifty persons. Each station has its hospital, with forty beds, its telegraph office, its storehouse, and its workshop. The natives build their huts round these villages, and furnish the inhabitants with supplies.

Mr. R. Nelson Boyd, a member of the Institute of Civil Engineers, read a paper before the Civil and Mechanical Engineers' Society, on March 30, 1887, in which he gave an account, from personal inspection, of the technical processes applied in the canal works, and pointed out that there was much waste of money and of valuable "plant." Omitting some remarks to the latter effect, because the faults he noticed may possibly have been amended since the date of his visit to the scene, and further progress must have been effected, we make the following extracts:

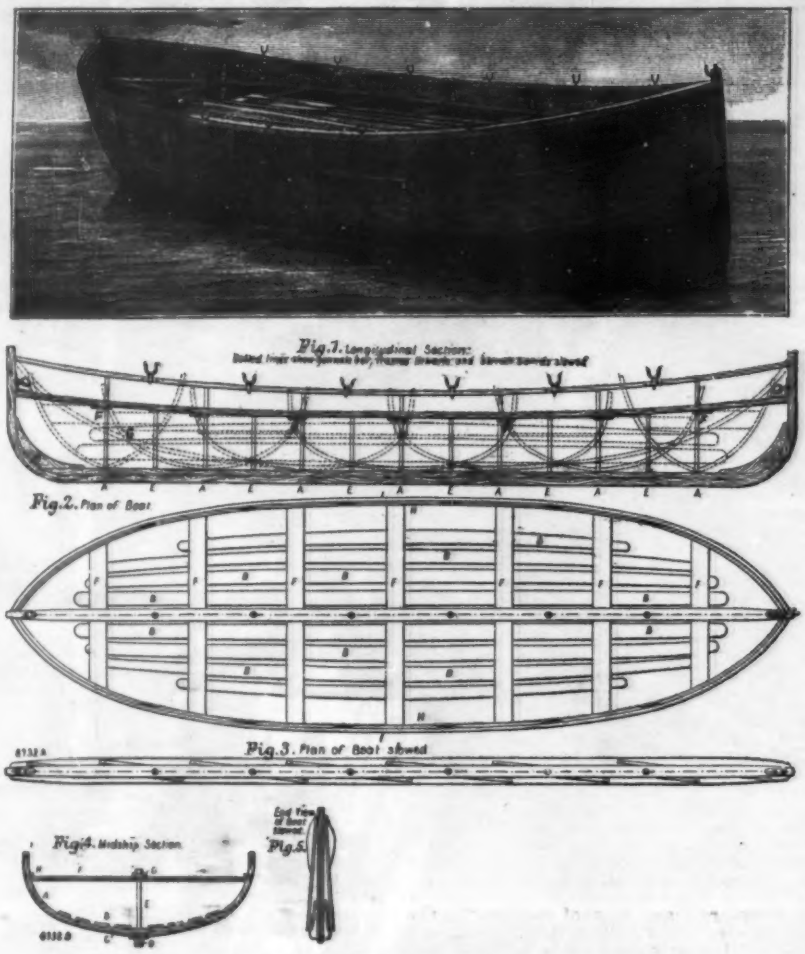
"At Colon the entrance to the canal has been constructed by making an embankment which protects it from the north winds, and has reclaimed ground formerly a swamp, on which the pleasant little settlement called 'Christophe Colomb' has been built. From the entrance the canal has been dredged to a depth of six meters for a length of four and a half kilometers, and is open for small steamers. Three very powerful steam dredges are now at work deepening the canal down to nine meters. After this comes a length of ground almost untouched, owing to disputes with the contractors. Then comes a length of six kilometers on the old bed of the Chagres, where dredges are at work deepening. These dredges have a power of 180 horse power, and raise about 3,000 cubic meters in the twenty-four hours. This seemed to me to be the best conducted work on the canal. From this on, all the earth in the cuttings is moved by hand labor, with the narrow gauge railway known as the 'Decauville,' or by the steam navvy or excavator, with full sized railway wagons. The engineers advocate the latter, because they can get more work done; but some of the contractors prefer the former method. The steam navvy Osgood at work on the Tabemilla section moves 300 to 360 cubic meters in ten hours; this section is almost level.

"At Buhio Soldado, a hill of about 65 meters in height is being removed by immense blasts of dynamite. After Tabemilla comes San Pablo, where the canal crosses the railway, and a turning bridge will have to be constructed. A few kilometers beyond this point comes Gamboa, where the proposed reservoir was to be, and then the immense cutting of Culebra across the watershed. This is the most important work to be done on the canal. The length of the cutting is 1,800 meters, and the deepest point of the cutting is 140 meters. The average for the total length is 88 meters. The height of 140 meters is not that of the center line, but the height of the summit of one of the slopes. The latter are 1 to 1, and the width at top of cutting will be from 200 to 300 meters. The quantity of earth to be moved is 20,000,000 cubic meters. At the time of my visit little work was being done, because a new firm of contractors had just taken over the cutting, and were making arrangements to suit their views. The previous contractors worked in steps, and used the small gauge Decauville railway and the steam navvy. Of the latter they had seventeen at work. Up to date about one-twentieth of the quantity has been moved, so that about 16,000,000 cubic meters remained to be excavated. This has been the work of six years. Of course much had to be done in preparatory work, such as laying roads for tipping, and getting the material together. However, as it now stands, it is estimated that it will require at the very least six years to finish it. The difficulties of this immense cutting are greatly enhanced by the nature of the ground, which is in great part composed of basalt rocks—dolomite—with bands of sand intervening. Several slips have occurred and occasioned much trouble. This point is the watershed between the Atlantic and Pacific Oceans, and from this on to Panama the canal is cut through comparatively easy ground. The only difficulties are the deviation of the Panama Railroad and of the River Grande."

For some kilometers before reaching the Pacific, the canal runs through swampy ground very little above sea level, and eventually joins the sea at La Boca, the mouth of the Rio Grande. Unfortunately, the water is very shallow here, and the last five kilometers have to be dredged through a bed of sand forming a wide bar at the mouth of the river. Three powerful dredges, of the Gouro pattern, able to raise 150 tons per hour, are here at work. When the canal was commenced, the necessity of locks and gates was suggested, owing to the difference of tide between the two oceans. The Atlantic tide at Colon rises 2 ft., whereas the Pacific at Panama rises 20 ft., and it has been ascertained that at low water the level of the Pacific Ocean is 3·25 meters —10½ ft.—below the Atlantic. The last proposal to obviate the ebb and flow of the Pacific tide was to construct a basin near the Pacific end 4,000 meters long by 500 meters wide, lined with strong quay walls and gates on the Colon side, which would be opened at high water. The cost of this work was estimated at fifty million francs. This, as well as other projects, has been shelved for the time, and the present intention is to construct an open canal from end to end. Its entire length, including the channel dredged in the Bay of Panama, will be 74 kilometers (45 miles and 1,729 yards); the width at bottom, 22 meters (or 72 ft.); at the top, 40 meters (131 ft.); and the depth of water 9 meters (29 ft. 6 in.).—*Illustrated London News.*

IMPROVED COLLAPSIBLE LIFEBOAT.

THERE are now being shown at the Glasgow International Exhibition several collapsible lifeboats constructed on the patented plans of Mr. J. W. Shepherd, of the Fairfield Shipbuilding and Engineering Company. This arrangement has been devised with the view of enabling ships to carry more boats without adding to the space occupied, a most commendable object. We annex engravings of one of the boats.



IMPROVED COLLAPSIBLE LIFEBOAT.

The length is 28 ft.; breadth, 8½ ft.; and depth, 3½ ft.; the weight being 11 cwt. 2 qrs. When folded up it occupies a space of only 11½ in. in width, and when expanded has buoyancy sufficient to carry sixty persons. Three of these boats could therefore be laid on the top of each other and lie under the ordinary lifeboat hung on the davits, or one could be stowed between the ordinary boats and the ship's rail when the usual boats are stowed on their chocks. The boats are strongly built, the woodwork being lined with angle steel galvanized. The frames work on a swivel and can be moved from athwart to be almost in line with the keel. When in sea-going condition, the frames are firmly kept in position by clamps and studs. The seats are hinged on the frames and on a runner supported above the keel by stanchions. The runner also strengthens the keel. The boats are covered with canvas of two thicknesses, coated with a composition to make it thoroughly water-tight, and on the bottom of the boat is the usual framework on which to walk. If the boats are found thoroughly seaworthy—and their adoption by the Cunard Company, who have ordered several of their large steamers to be provided with them, may be taken as a guarantee of this—then the boats meet a decided want. The capacity of the boats carried by large passenger steamers is often insufficient to accommodate all on board, and the arguments used by owners against their provision is usually that they would monopolize too much deck space; and frequently passengers support this contention. Mr. Shepherd's boat is one of two or three boats designed to meet this objection.—*Engineering.*

THE BIG WARRIOR BRIDGE NEAR CORDOVA, ALABAMA.

THE consolidated lines now known as the Kansas City, Fort Scott & Memphis Railroad extend from Kansas City to Memphis, 487 miles, and the Kansas City, Memphis & Birmingham, operated by the same officers, and largely owned by the same interest, extends from Memphis to Birmingham, 251 miles.

The latter line crosses the Big Warrior River near Cordova, in Alabama. Two spans of a single track through bridge carry it over this stream. One of these spans is 150 feet in length and of the ordinary parallel chord, Pratt type, while the other is 298 feet long between centers of end pins. The latter is shown in the accompanying engraving.

Although it is not an extremely long span, it is far

BIG WARRIOR RIVER BRIDGE, MEMPHIS AND BIRMINGHAM RR.

beyond the average length of ordinary railroad structures, and required in its design the consideration of features characteristic of economy in the heaviest railroad bridges. This road opens the West and Northwest to the coal and iron country of Northern Alabama, and the interchange of the heaviest kinds of freight traffic between those portions of the country is induced by it. Hence its bridge structures are required to be of the most substantial character and to meet unusual demands.

The general view gives the features of the design. The reduced depth at the ends of the truss is an economic feature which has long been recognized in the best engineering practice, but its combination with a single system of triangulation for the web members in long spans is of recent date and places this structure in the first rank of American bridges.

The entire structure is of wrought iron throughout, and every detail exhibits scrupulous care in its design. The floor beams are riveted between the vertical posts above the pins, and the longitudinal stringers are secured in the same manner between the webs of the floor beams. The maximum stiffness of floor is thus secured and the general stability of the span much enhanced. The complete upper and lower lateral and transverse systems, in connection with the heavy lattice portal bracing, insure the highest degree of stiffness and stability under high speed traffic, or even in cyclones.

The horizontal rod running longitudinally at mid depth of the trusses is for the sole purpose of preventing vibrations in the long posts of the web, and was not considered to affect in any way the column length of these posts.

This span was subject to a very severe test immediately after the removal of the false work and before the rivets in the upper chord joints were driven. While these joints were temporarily bolted, it became imperatively necessary for the railroad company to pass trains over the bridge. Under these trying circumstances it carried its traffic in the most satisfactory manner.

The entire structure was designed, constructed, and erected by the Phœnix Bridge Co. for the moving load given in their standard specifications, and consisting of two coupled consolidation locomotives, each with its tender weighing 171,000 lb., followed by a train load of 3,000 lb. per lineal foot. It was completed in the early autumn of 1887.—*Railroad Gazette.*

THE KRUPP RAPID FIRING GUN.

IN the warfare of the present day, special weight is rightly given to the most effective utilization of materials. The attempt to attain the greatest initial velocity with the heaviest projectiles has met with a certain success in the universal introduction of the breech loader, and efforts are now being made to greatly increase the rapidity with which the guns are fired.

This object is generally accomplished by the use of the metal cartridge, borrowed from the rifle, which unites the ball and the charge of powder in one body, renders the special arrangement of the breech to make it gas tight unnecessary, and carries in itself the means of ignition.

Although there are many ways of constructing the breech mechanism so as to facilitate rapid loading and firing, the basis of the cartridge is the same for all, and in this common basis the limit of the caliber has heretofore been given, for the difficulty of manufacturing a suitable metallic shell having proper power of resistance increases very rapidly with the size of the caliber.

Of course, the firm of Krupp early turned its attention to this new weapon, and is, therefore, now in a position to place upon the market a series of guns having calibers ranging from 4 cm. to 13 cm. which fire projectiles weighing from 1·6 lb. to 60 lb.

Our engraving shows a Krupp 7·5 cm. rapid firing gun of 40 caliber length, with a ship's carriage and an armor shield. With this cannon two kinds of projectiles weighing 13·6 lb. and 11·7 lb. respectively are used, which, with a 6 lb. charge of powder attain an initial velocity of 623 yards and 667 yards respectively. The heavier projectile has a range of 9,076 yards with the maximum elevation (25°) of the carriage, and will penetrate a plate of soft iron 5 in. thick near the muzzle, and a plate 3 in. thick at a distance of 1,000 yards.

The ballistic properties of the gun are very great, and if it is taken into consideration that the gun is capable of firing from 17 to 20 shots per minute, an idea of the extraordinary amount of work which can be done is obtained. Krupp's other rapid firing guns are proportionately rapid, the only difference being that the rate of firing decreases in the larger guns. Thus the 10·5 cm. gun fires about 15 shots per minute, and the 13 cm. gun about 12 shots per minute.

Only two men are required for the manipulation of the gun. One of them occupies the seat connected with the carriage, and follows the sidewise movement of the gun. He takes aim, fires, and opens and closes the breech. The second man only has to bring the cartridges and put them in place. The empty shells are thrown out and the weapon is cocked automatically by opening the lock. Besides the vertical breech shown in the illustration, this firm also makes a horizontal breech for rapid firing guns, which offers special advantages for heavy calibers.

The mounting of the quick firing guns varies according to the use for which they are intended. Our cut shows a ship's carriage with an armor shield, but they also build carriages for stationary guns in forts, for the defense of trenches, etc., as well as portable carriages for forts and for the field. This weapon will, without doubt, make a permanent place for itself, now that it has been made practical.—*Illustrirte Zeitung.*

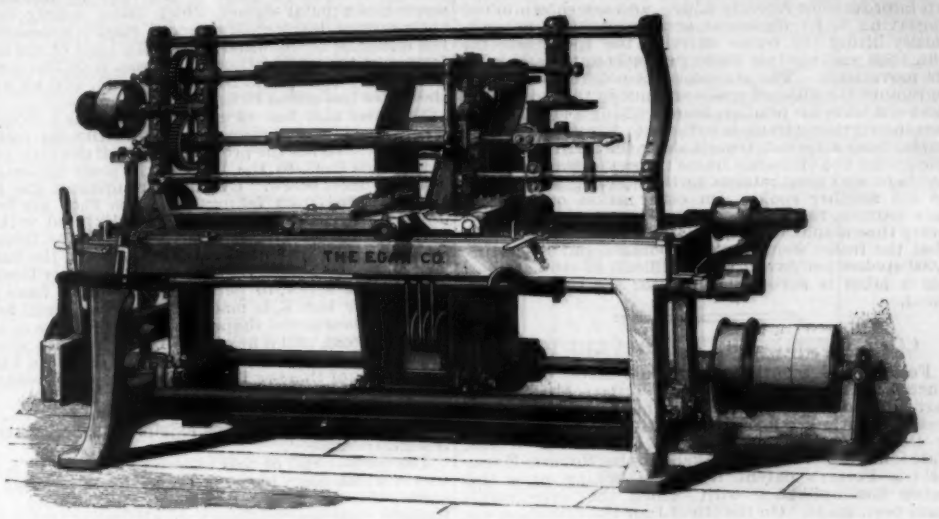


FIG. 1.

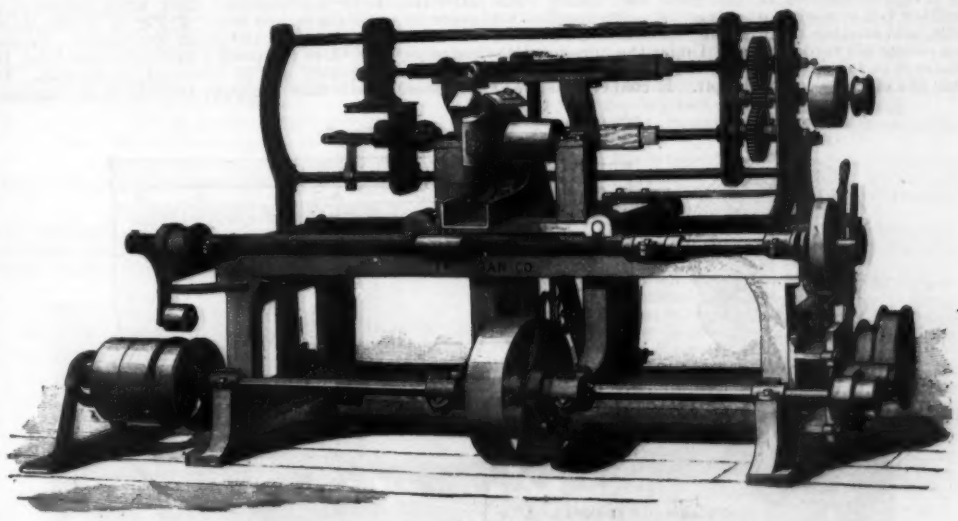
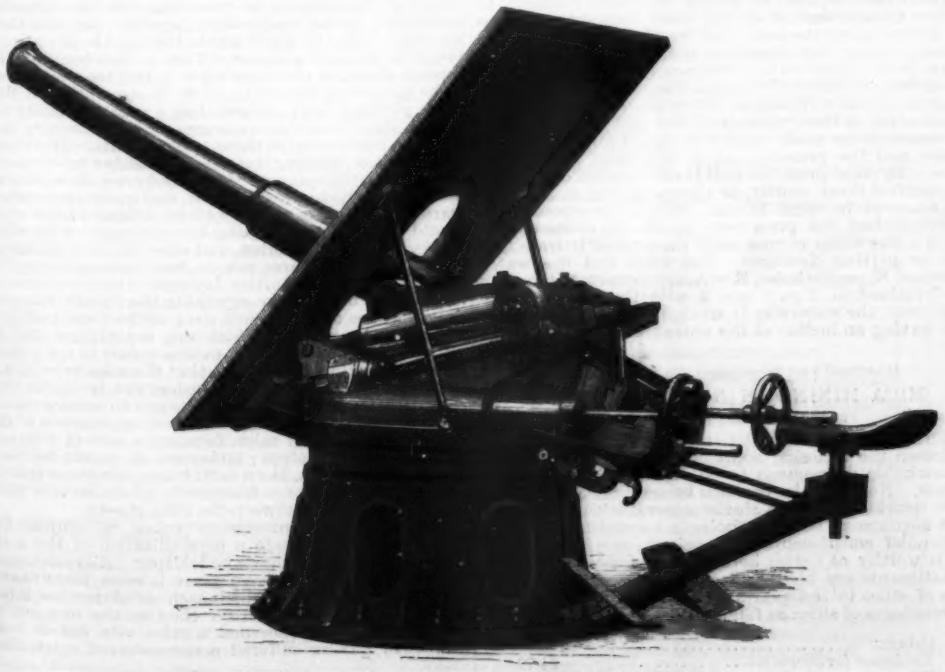


FIG. 2.



THE KRUPP RAPID FIRING GUN.

IMPROVED AUTOMATIC SPOKE LATHE.

AUTOMATIC SPOKE LATHE.

As showing the progress of American machinery in Europe, we take the following engravings and description from a recent number of *Iron*, published in London.

An automatic spoke lathe of advanced pattern with screw feed will be found illustrated above. We show at Fig. 1 a front and at Fig. 2 a rear view of the machine. It was designed and is manufactured by the Egan Company, of 160 to 180 West Front Street, Cincinnati, Ohio, U. S. A., and it combines the Blanchard lathe with their improvements, and they claim that it has a capacity of fifty per cent. more work than any other spoke lathe. The bed or frame is very wide and heavy, with the V placed some distance back of the center line of the cutter head; this allows the belt to press the front of carriage down to the V as it travels along. The bed is also constructed in such a manner that no chips can accumulate on the top to obstruct the rollers. The sliding carriage has four rollers with large journals held in position by large collars on the outside; the carriage is provided with adjustable gibs to the main frame, thus preventing any side play. The standards carrying the cutter head are bolted to the carriage on the planed surfaces, thus making a strong and reliable cutter head frame. The head is entirely new, a combination of hook and gouge knives; the entire surface is turned true, with a large crucible steel mandrel and long journals, making a reliable and perfectly balanced cutter head. The vibrating frame, which is cast hollow, is connected at the top by a hydraulic pipe, combining strength with lightness for vibrating. Adjustable trunnion boxes are provided to change the size of the spoke. The gearing is cut from the solid, the center one being of steel with double width of face, to enable the operator to change the shape of the spoke. The centers are made of best cast steel, fitted to large steel mandrels; the back center bearing is so constructed that various lengths of spokes can be turned from one pattern—a very desirable feature for any spoke factory. The eccentric center is very large, requiring no ratchet to keep the spoke in position while being turned.

The spring pressure bar is provided with three cast steel coil springs, connected to the carriage with a slide working in planed ways operated by a hand wheel and screw, and so constructed that anything, from the smallest buggy spoke to the largest wagon spoke, can be turned with ease. All the vibrating rests are made of steel. The feed mechanism is simple and reliable, and is constructed so as to change the speed of feed at the throat of the spoke, but with a slight change it

can be made to feed at one rate of speed the full length of the spoke, which is a great advantage. By pressing a small lever, the feed can be stopped in any desired position along the spoke for setting the rests or truing the knives. The feed screw is made of steel, with an adjustable nut to take up any wear that may occur. An improvement recently added, and not shown in our engraving, is an ingenious arrangement for automatically lifting the frame carrying the spoke into the cut, thus making this lathe perfectly automatic in all its movements. The operator has nothing to do but to remove the finished spoke and put in the stock. He does not leave his position, merely lifting a lever, which sets the vibrating frame into the cut; the carriage, with cutter head attached, travels along the bed, completing the spoke, the vibrating frame throws forward and the carriage and head returns to the starting point ready to cut another spoke. On other makes of lathes of this pattern, this frame must be lifted into the cut every time a spoke is turned, and when it is considered that the frame weighs over 35 pounds, and estimating 1,000 spokes per day, it is not difficult to estimate how much labor is saved the operator by this improvement.

COAL GETTING BY HYDRAULIC PRESS.

FOR several months experiments have been conducted at Kiveton Park collieries, near Sheffield, to test the practicability of bringing down the coal by means of hydraulic machinery. Messrs. Mallet, Porter & Dowd, of the North London Engineering Works, Caledonia Road, are the makers of the Roberts-Horsefield & Porter's patent hydraulic mining press, this being the appliance with which the experiments have been made. On the 5th of June the invention was shown in operation at Kiveton Park colliery to a number of representatives of the press and others. The Barnsley bed is worked at this colliery at a depth of 4 0 yards, and another shaft is being sunk to the Parkgate seam, some 250 yards deeper. Under the mines regulations now in force, all blasting must be done at night, when the men are out of the pit. If coal can be got at

Fig. 1

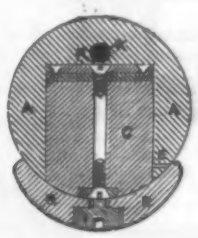


Fig. 2

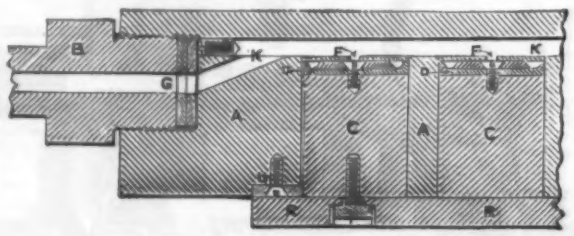
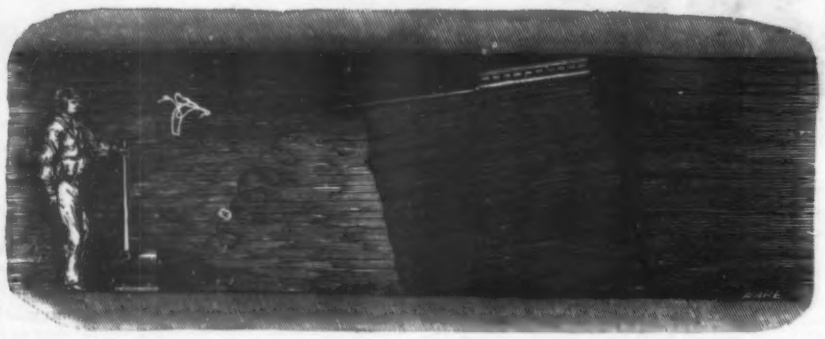


Fig. 3



ROBERTS-HORSEFIELD & PORTER'S HYDRAULIC MINING PRESS.

without blasting or explosions of any kind, it follows that the work can be carried on by day and night. With the Horsefield appliances the coal is holed, as usual, with a drill, the press—of which a detailed description follows—is inserted at the roof of the coal to the back of the bore hole, and connected by copper tubing to a small hydraulic pump which forces the water into it. In the press are fitted a series of rams acting on a longitudinal segment or plate. When the water is applied, the rams immediately begin to expand, and the coal falls gently forward. This we saw successfully done in No. 6 stall. A mass of coal, 4 ft. 6 in. thick, had been "holed." In about four minutes from the application of the press the rock-like face emitted a low, rumbling sound, followed by crackling, and what the underground workers call "colliers' music."

The solid wall literally came forward, with very little noise and singularly free from dust, considering the mass dislodged. On the results being measured, the quantity brought down was found to be 4 ft. 6 in. in depth, 4 ft. 6 in. width, and 33 ft. in length. This is equal to rather over 24 tons, and practical coal getters will appreciate the statement of work done. We talked with the miners who have been working the machine, and they were unanimous in its praise. Mr. Soar, the under manager, informed us that all the private experiments conducted in the pit had been uniformly successful. The average quantity brought down during the private trials has been 10 to 13 tons each "shot." No doubt further trials will be conducted in the fiery pits of Barnsley, where such an invention would be of more service than at Kiveton Park, which is considered exceptionally free from danger. There seems no reason to apprehend any failure on the part of the press in subsequent experiments. The face of coal it operated upon at Kiveton was very hard, and therefore afforded satisfactory test. If further trials are equally satisfactory, the Horsefield invention seems to solve the problem of coal getting without explosives. The promoters claim for it absolute safety in using, that it makes no slack, bringing the coal down in bulk—this was particularly evident on June 5—that it is 50 per cent. cheaper in working, that the coal is broken down from the back of the hole, and that there is neither dust nor fumes, while watering is unnecessary.

The following are the details of the press, Figs. 1 and 2: A is a cast steel bar containing a number of circular cavities, in which are placed rams of steel. These rams are fitted in the circular holes of the bar so as to act freely; on the top of each ram is placed a cup leather, *d*, which is fixed to the rams by means of a screw and a metal washer, which latter nearly covers their surface, leaving only a small margin accessible to the influence of the water. Over the head of the screw fastening the cup leather to the ram is drilled a small hole which opens into the waterway, *k*, and by which the water has access to the top of the rams, *c*.

The first and last ram in this press has a groove in its outer side which runs nearly up to the cup leather. In this groove fits the prominent part of the little plate, *u*, which is fixed to the body of the press by means of a strong steel screw. By this arrangement the rams are prevented from falling out when they are forced down. The press, however, is generally used with the rams moving upward. On the bottom of the foremost and last ram is fixed, by means of screws, I, the bar, R. The clearance hole in this bar is a little larger than the head of the screw, to permit the latter to have play room. The bar, R, is made of the same metal as the press. It is crescent shaped, with a thickness of ¼ in. at the bottom, and a height of 1¼ in. It fits exactly round the lower part of the press, as shown in Fig. 2. The object of this bar is to secure an equal pressure to the rams when working against a solid surface. The waterway—Figs. 1 and 2—has a diameter of ¼ in., and is in a straight line, except at the entrance, where it is slightly inclined.

The further end of this waterway is closed by a steel screw, which has a hexagon head. By taking out this screw, the waterway can easily be cleaned. The straight waterway enables a simultaneous action to be obtained. To prevent the rams being overstrained after they have accomplished their work, provision is made by means of escape holes, E, Fig. 2, in the walls of the cavities on which the rams are placed. To the entrance hole, G, of the press a hydraulic steel tube, B, 2 ft. 9 in. long and of 1 in. diameter, is screwed. To this steel tube is fixed a copper tube ⅛ in. in diameter and of $\frac{3}{16}$ in. bore. This tube may be from 10 ft. to 14 ft. long, as required, and is fixed with the remaining free end to the force pump. Any hydraulic pressure pump may be employed; the one we saw used was a Tangyes' portable, weighing 42 lb. The copper tube, spirally bent, is used to secure sufficient elasticity to follow the movements of the press during the process of forcing down the coal. At the distance the pump is placed—about 10 ft. from the coal to be operated on—there is no danger to the workmen in attendance. The press weighs only 40 lb., has a diameter of 3 in., and a length of 22 in. Of course, the makers do not restrict themselves to these measurements and weights. The presses may be made smaller or larger for special purposes, and the pressure can be increased to suit any case. By this press the coal is not crushed or broken, but shifted down gently, as shown in Fig. 3, and can be removed in large blocks. When the operation is accomplished, the press rests on the top of the coal as shown, the spiral copper tube preventing it from falling or getting damaged. The rams and the water passage, K, escape holes, E, etc., are constructed exactly as explained in Figs. 1 and 2, with the simple exception that the waterway is straight throughout, without having an incline at the entrance.—*The Engineer.*

[Continued from SUPPLEMENT, No. 654, page 10449.]

MICA MINING IN NORTH CAROLINA.

By WM. B. PHILLIPS.

THE free play which the crystallizing forces enjoyed between the inclosing walls of the vein is one of the remarkable phenomena to be observed in these mica mines. Nowhere else can this be seen on such a scale. The development of a single mineral within a vein is not uncommon, but the wholesale crystallization of all the chief constituents of a vein is very infrequent. It is worthy of notice here that in a mica vein these constituents are highly siliceous. Taking the percentage of silica in the quartz as a standard, we have the percentages of silica as follows:

	Per cent.
Quartz	100
Feldspar (orthoclase)	64·72
Mica (muscovite)	45·75 to 51·80
Garnet	35·00 to 39·11

Garnet is here included because, although it does not occur in large crystals, it is nearly always present, and in considerable quantities, sprinkled in the quartz. This, so to speak, excessive extension of the crystals would seem to imply that they met with but little resistance, or that the resistance was easily overcome. W. C. Kerr was of the opinion* that many of the irregularities of these veins, in form, size, and position, were due to the efforts of the vein matter to intrude itself. These irregularities, however, seem to me to be chiefly due not to this cause, but to the original fissuring forces. It may indeed be true that in the attempt to *crystallize*, the vein matter caused some irregularities in the shape and size of the fissure, but this is a force different in kind and degree from the intrusive force referred to. In the work of intrusion the temperature of the intruding mass would have been lowered. As this process went on, and more and more work was accomplished, the temperature would tend more and more toward the point at which crystallization would set in, unless a new source of heat was at hand and available. The amount of heat given out by the solidifying vein matter would of course be the same as was absorbed by it in first assuming the liquid state. Whether the amount of heat equivalent to the effect of intrusion would be less than equal to or greater than the amount thus set free is a question upon which I do not now propose to enter. The subterranean forces causing the ascension of the vein matter in a liquid or semi-liquid condition could have forced it into the various ramifications of the fissure and have thus left it to follow its own crystallizing tendencies. That there was little or no hinderance to it in passing to the solid state is shown by the size of the resulting crystals. The great and extended irregularities in these veins I would therefore attribute primarily to the original fissuring forces, the small and more local ones to local causes, among which may be included local intrusion and local crystallization.

At whatever point within the fissure we consider the vein matter, whether before or after crystallization, it will appear as completely filling it. A "horse" within a mica vein is seldom met with. There is one at the Sink Hole mine. Here the inclosing rock is mica schist, and the following succession of substances has been observed from wall to wall:† 1st, mica; 2d, a "horse" of mica schist; 3d, smoky quartz; 4th, mica; 5th, smoky quartz; 6th, a "horse" of mica schist; 7th, mica.

The deposit of mica between the "horse" and the wall is narrow, but yields good mica. The greater part of the mica in the vein crystallized first, and probably in this process tore off a piece of the wall, the space left by it being subsequently filled with mica. The pieces torn off are somewhat more decomposed than the original walling.

The direction taken by the mica crystals is not without interest. As a rule, the plane of crystallization, parallel to the laminæ of the mica, is more or less inclined to the line of strike, being frequently perpendicular to it, so that the mica on being uncovered resembles a pile of thick planks laid flat on the sole of the level. I do not recall an instance of a contrary arrangement, *i. e.*, of a parallelism between the plane of lamination and the line of strike. The tendency is strongly the other way.

An interesting question here is whether the mica, feldspar, quartz, garnet, etc., existed as such within the vein, and had only to segregate themselves by crystallization, or whether they are to be regarded as forming within the liquid mass highly complex silicates, which crystallized according to the chemical affinity of their constituents under the existing circumstances. According to the first view, the mica probably existed as $H_4K_2(Al_2)Si_4O_{14}$, the feldspar as $K_2(Al_2)Si_6O_{16}$, the garnet as $R_3^{II}(R_2^{VI})Si_3O_{12}$, where R = Ca, or Fe, or Mg, and $(R_2) = (Fe_2)$ or (Al), and the quartz as SiO_2. They existed *as such*, and had only to crystallize to become visible.

According to the second view, the potash, alumina, lime, magnesia, iron, and silica were all in a state of aqueo-igneous fusion together; some of the potash and alumina laid hold of the requisite amount of silica and became mica; another portion of potash and alumina and silica formed feldspar, etc.; the portion of silica not needed for these compounds finally crystallized as quartz. In neither case could crystallization occur until the critical point (congelation point) for each substance was reached.

The various chemical elements in the vein matter would at the moment of crystallization have affinities influenced by the temperature, pressure, etc., and these affinities might or might not be the same as at ordinary temperature and pressure. That a high heat does influence chemical combination is a fact too well known to be more than restated. Thus it is well known that at a glowing heat oxygen has a greater affinity for carbon than for either hydrogen or iron, strongly as it tends to combine with these two elements. The chemical affinities existing between a number of elements under the circumstances of heat and pressure in a liquid mass from which mica, feldspar, and quartz were afterward to crystallize might well be different from what would obtain if the limiting circumstances were withdrawn. Potash, alumina, and silica do not combine at ordinary temperatures, nor do lime, iron, and silica.

Whatever the affinities between these substances might have been before crystallization, when this process was once established it went on to form perfectly definite compounds. Which one crystallized first is not so quickly said. From evidence now in my possession, I am inclined to believe that the mica crystallized first. I was led to this conclusion, not by theoretical considerations, but by having found in a mica vein a piece of quartz having on it evident impressions of the edges of a block of mica, forming a sort of pyramid with microscopic steps; inclosures of quartz between the laminæ of mica, the quartz being almost as thin as the mica; inclosures of feldspar in mica also very thin, and lying pressed between the mica sheets.

These three circumstances taken in conjunction would seem to indicate a crystallization of the mica prior to that of the quartz or feldspar. A synchronous crystallization would have given a mass more nearly resembling granite, in which each substance has interfered with the other. So far then as the moment of crystallization is concerned, a mica vein differs from granite in having suffered a succession of crystalliza-

* *Engineering and Mining Journal*, vol. xxxi., No. 13, p. 211.
† W. C. Kerr, *ut supra*.

tions instead of synchronous crystallization. Had the mica, feldspar, and quartz all crystallized at the same time, there is no reason why there should not have been granite in the fissure instead of a mica vein.

It will appear from the preceding discussion that a mica vein is only a vein of very coarse granite in which the forces of crystallization have had comparatively free play. The resulting crystals are of great size, and have interfered but little in each other's development. So far as the texture of the vein is concerned, it is as different from that of ordinary granite as a collection of single crystals of large size is from an agglomeration of crystals of small size. The almost exclusive occurrence of well crystallized quartz would seem to indicate a solidification from a fluid or semi-fluid mass of aqueo-igneous origin, rather than from a fused mass of purely igneous origin.

For the production of such large crystals the mass must have solidified very slowly, and have met with but little resistance. The view that the dislocation of the inclosing strata was in part due to the intrusion of the vein can be accepted only with caution. What are the inclosing rocks, and how are they related to the mica veins?

The inclosing walls are for the most part dark gray mica schists, more or less hornblendic, somewhat decomposed toward the surface but becoming harder farther down. At some mines, for instance, the Presnel in Yancey County, and the Pt. Pizzle (Cloudland) in Mitchell County, the inclosing rock has more of the appearance of a schistose gneiss. But even where it is most gneissic it is still highly micaceous and hornblendic. An interesting occurrence is at the Balsam Gap mine, in Buncombe County, on the Black Mountain, at an elevation of 3,500 feet.* Here the walling on both sides is a slaty gneiss, which offered such resistance to the fissuring force that the fissure stopped short of the surface, and there lies above the mica a capping of gneiss. It may be, of course, that the erosion there was not sufficient to remove the capping, while at other mines now showing outcrops of mica veins the rock did not oppose such resistance. Because a mica vein outcrops now, we may not be warranted in assuming that it always outcropped. In cases where the original outcrop has been covered over by newer formations, the explanation is simple; but where the vein never reached the surface at all, as probably at this mine, it is not so simple. Gaetzschman† would seek to explain such an occurrence by supposing a considerable lapse of time between the opening and the filling of the fissure, especially if fragments of the walling were included in the vein. That such fragments are thus included in mica veins will appear from the discussion in the first article of this series.

The inclosing rocks, whether micaceous schists, slaty gneisses, or gneissoid micaceous schists, have a general strike toward the northeast, and a general dip toward the southeast, at angles varying from 40 to 90 degrees. The mica veins share these characteristics more or less completely, and are hence bedded veins.

So far as known, the walling is the same on both sides of the vein. Contact deposits do not occur in this region as they do at the junction of sandstones and schists near Mts. Lincoln and Bross, in Colorado.‡ When the Silvers or Sink Hole mine was first opened in 1868-69, the upper part of the vein was a decomposed feldspar, at 20 feet depth this passed into granite, and at 60 feet the vein narrowed so that work was suspended for awhile.§ The vein was afterward found to widen again, while still in granite.

Good crystals of mica, sometimes of several inches in dimension, have been observed in Prozoic granites of the Sweetwater District, Idaho,‖ as also in the granite of the Black Hills.¶

At this latter locality they form about 5 per cent. of the granite, this proportion, as will hereafter appear, being somewhat below the average yield of "cut" mica from North Carolina "block" mica. It is interesting to note also that the crystals of mica in the granite occur in bunches or segregations, a phenomenon likewise characteristic of some Mitchell County mines.

The inclosing rocks in North Carolina have suffered many and great dislocations. They are bent, curved, and twisted in a variety of ways without, however, giving rise to faults in the vein. The irregularities of the veins, therefore, are those of form, size, strike, and dip, rather than of position. It must not be forgotten that the rocks of this district have suffered enormous erosion and denudation. They are among the very oldest rocks of this continent, and probably have not been submerged since the Cambrian period. We have in them the unmoved remains of the old crystalline rocks, and what is now exposed to our view was formerly overlaid by rocks of the same age. When this plateau was elevated, with its border of high mountains on every side, the fissures now filled with the mica veins were opened. The fissures most naturally followed the line of least resistance. Where this coincided with the line of bedding, a true bedded vein resulted. Where, on the contrary, it ran somewhat transverse to this line after having followed it for some distance, the vein assumed more of the character of a lode. This seems to me the true explanation of an occurrence sometimes met with, as at the Pizzle mine, where the vein, after coinciding in strike and dip with the inclosing schists, suddenly breaks across the stratification and changes its dip.

The mica veins in North Carolina are true fissure veins, differing in this respect from the mica veins of New Hampshire, which, according to N. S. Shaler,** "appear to be obscure beds closely following the general run of the apparent bedding that characterizes the granites in this part of the country."

Hitchcock†† ranks the Grafton mica veins in the gneissic series, and says that valuable deposits are found only within the fibrolite area (mica schist with fibrolite, one of the supposed divisions of the Montalban Group). This fibrolite area lies in between the two great areas of porphyritic gneiss, very well developed between Rumney and Hebron.

Of the influence of the walling on the quantity and quality of the mica, but little is known. My own investigations on this subject have not as yet led to any definite conclusions. Some of the more experienced miners in Mitchell County say that both the quantity and the quality of the mica depend upon the character of the walling and of the vein, but the lack of careful and long continued observations, conducted in a methodical and scientific manner, precludes the formation of definite and reliable opinions. There are so many accessory circumstances that influence the quality of the mica, such, for instance, as the width of the vein, the presence of flat and curved mica, of crystallized feldspar, etc., that the time has not yet come for expressing an opinion. These circumstances may depend more or less upon the character of the walling; but if so, it is not known just what the connection is. The same may be said as to the influence of width, depth, dip, strike, and accompanying minerals.

Below the zone of atmospheric influences, rarely extending below 20 feet, and sometimes not below 10 feet, the vein becomes more solid, and the quality of the mica improves. The width of the veins varies widely, from 3 feet to 40 feet, sometimes in the same mine varying from 3 feet to 20 feet, as at the Presnel mine, Yancey County. Nipping of the vein is a common occurrence, occasionally to almost entire obliteration. It has frequently happened that one set of miners have quit work on account of a "nip," and another set at a subsequent date have prosecuted the "driving," and found good mica within a few feet. The "stringers" that make off from the main vein penetrate into the wall rock at various angles, and though narrow sometimes, yield fine mica.

The occurrence of well crystallized feldspar is held to be a sure indication of fine mica, though flesh-colored feldspar is regarded as exerting an injurious influence, as also the preponderance of quartz, and the presence of uranium minerals. These assertions must, however, be accepted with caution, or, as a Teutonic friend once remarked, "with a big dose of salts."

(To be continued.)

* Figured and described by W. C. Kerr, *Engineering and Mining Journal*, vol. xxi., No. 13, p. 212, and Trans. Amer. Inst. Min. Engs., 1880.

† Auf- und Untersuchung Nutzb. Mineralien, Leipsig, 1806, p. 92, where many similar occurrences are noted. Compare also Von Cotta, Erzlagerstatten, I Th., 1850, p. 118; Grimm, Lagerst. der Nutzb. Miner., 1869, p. 100.

‡ U. S. Geol. and Geogr. Survey of Colorado, 1873, p. 269.

§ D. A. Bowman, Mitchell County, priv. com., Nov. 5, 1887.

‖ U. S. Geol. and Geogr. Survey of Idaho and Wyoming, 1877, p. 158.

¶ U. S. Geol. Survey, Black Hills, 1880, p. 70.

** Tenth U. S. Census, vol. xv., p. 893.

†† Geol. of New Hampshire, vol. i., 1874, p. 26, and vol. iii., part v., p. 99.

[NATURE.]

PHOTOGRAPH OF THE EYE BY FLASH OF MAGNESIUM.

THE effect of complete obscurity on the normal pupil has hitherto been seen only by the light of electric discharges, which allowed of no measurements.

MM. Miethe and Gaedicke, by their invention of the well-known explosive magnesium mixture, have furnished us with a simpler method. A photograph of the eye can be taken in a perfectly dark room, showing the pupil fully dilated, as its reaction does not begin until after exposure.

Mr. Miethe, astronomer at the Potsdam Observatory, himself at my suggestion undertook to execute the accompanying photograph of a normal eye, life size, after a quarter of an hour's rest in a carefully darkened room. The pupil was found to measure 10 mm. horizontally (the breadth of the cornea being 13 mm.). A reflection of the flash is seen on the cornea.

This kind of photography may prove a new and valuable method for many other branches of scientific research, but it is of especial utility to ophthalmology, as the eye, by its mobility and sensitiveness, has hitherto been a most difficult subject for the camera.

CLAUDE DU BOIS-REYMOND.

PHOTOGRAPHS OF PROJECTILES IN MOTION.

CAPTAINS Mach and Salcher have recently published a pamphlet at Vienna which has attracted much attention, and in which is given a reproduction of some photographs of bullets in motion. The experiments were performed as follows:

As it was necessary to be able to illuminate the projectile brilliantly and instantaneously, the use of nothing but electricity could be thought of. To this effect, Capt. Mach ingeniously made use of a battery of Leyden jars, with two points of interruption, one of which consisted of wires inclosed in glass tubes. In its course the projectile broke the tubes, and thus caused the discharge of the two points of interruption.

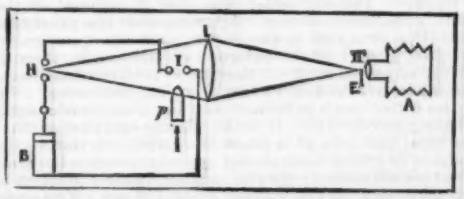


FIG. 1.—Diagram of the Process of Photographing Projectiles during Flight.

The spark, on leaping to the second point of interruption, illuminated the projectile, the image of which was instantaneously taken by means of a photographic apparatus placed very close by. The illumination was found to be most favorable at a distance of seven millimeters only from the spark.

The first experiments were not a success, because the velocity of the projectile was less than that of sound. But with a Werndl gun, whose initial velocity is 438 meters per second, as well as with a Gneder gun, which has an initial velocity of 530 meters, a beautiful, sharp image of the zone of compression of the air was obtained. This stratum appears on the photograph in the form of a hyperbola surrounding the projectile, of which the summit is at the head and the axis of the trajectory.

Bands of demarkation start from the posterior end of the projectile and separate as they extend back. The compressed and condensed air cannot expand with a velocity greater than that of sound.

Photography has confirmed that hypothesis of a hyperbolic form of the compressed air which Capt. Mach had already put forth.

With a ball projected with very great velocity, there

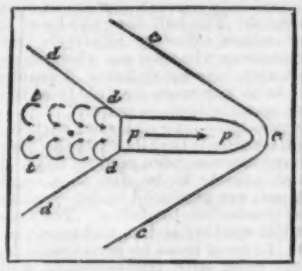


FIG. 2.—Diagram of the Photographic Image of the Projectile during Flight.

is again shown that remarkable fact that in the part deprived of air that follows the projectile there occur small clouds which form a train in the rear. Gyratory motions may be clearly distinguished therein. The photograph of a projectile renders perceptible a motion of the air having a resemblance to the motion of water around a boat moving forward with great speed.

It appears useful to present a few observations on the subject of this work.

A bullet that has a velocity of 500 meters per second moves 5 mm. in $\frac{1}{100000}$ of a second. Now, we do not believe it possible to produce a spark of any strength in so short a time.

Even admitting the fact, the image would not have much sharpness, since the lines would spread out over 5 millimeters.

Upon examining with care the well executed figures accompanying the memoir under consideration, it seems evident that they are lithographs drawn by hand and probably reduced by photo-engraving, but not photo-engravings obtained directly from photographs.

We do not deny that Capts. Mach and Salcher obtained photographs of projectiles in motion, but it seems to us that these operators have reproduced upon their drawings what they thought they saw in the more or less confused photographs that they obtained.

The phenomena established by these officers are, on the whole, in accord with those established a long time ago at the Normal Shooting School by direct observation, as follows: The gun (Fig. 1) was placed upon a

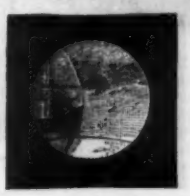


FIG. 3.

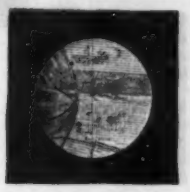


FIG. 4.

FIG. 3.—Projectile of the Gun Werndl. Speed, 438 meters. Wave of condensation in front of projectile. FIG. 4.—Conical Projectile of the Gun Werndl. Speed, 438 meters per second. Wave of condensation in front.

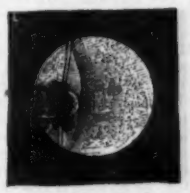


FIG. 5.

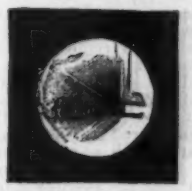


FIG. 6.

FIG. 5.—Projectile Werndl, showing the Electrodes and the Waves of Condensation. FIG. 6.—Projectile of Gneder Gun. Speed, 530 meters per second. Waves of expansion and whirlwind behind the projectile.

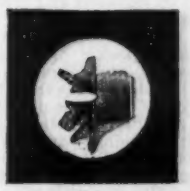


FIG. 7.

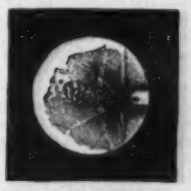


FIG. 8.

FIG. 7.—Projectile of Gneder Gun. The vertical line represents the electrodes, and the waves of condensation are seen around the projectile. FIG. 8.—Projectile of Gneder Gun. Waves of expansion, electrodes, and whirlwind behind. A sound wave produced by the spark is seen behind the projectile.

REPRODUCTION OF PHOTOGRAPHS OF PROJECTILES DURING FLIGHT.

carriage. In the rear and in the plane of firing, a strong telescope was placed. This latter could be placed very near the prolongation of the axis of the barrel if the firing was done with the new smokeless powder. It had to be placed at a distance of 30 centimeters above such axis if the firing was done with black powder, and yet in this case no observation could be made unless there was a strong side wind to remove the smoke.

In operating thus, the balls can be very well followed for a stretch of 200 meters (between 100 and 300 meters, for example), even when they start at a velocity greater than 600 meters. The length of time during which they are seen is more than half a second, and, when the organization is good, this observation can be repeated as often as is desired.

Thousands of projectiles have thus been observed at the camp of Chalons at the above named school.

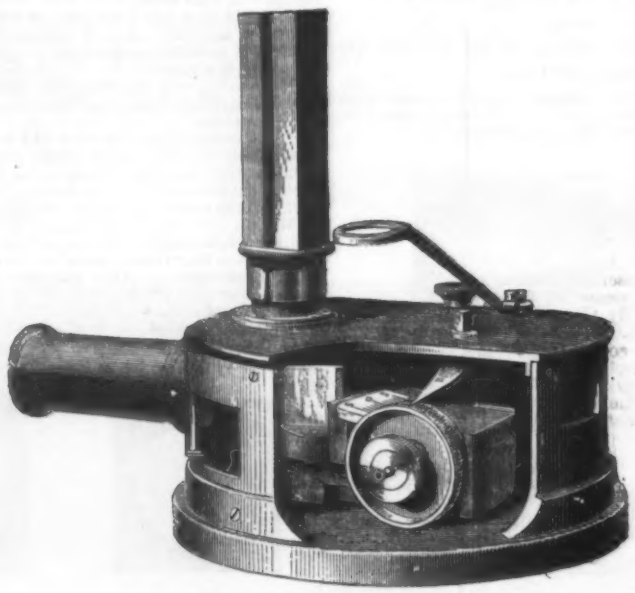
When the velocity is great, the aspect observed is that shown in Fig. 2. The ball seems to be at the apex of a cone of air whose sides are relatively thick. On the whole, we observe what we see when we move a body rapidly in water. As for defining it exactly, that does not appear to us any more possible than to do the same with waves or whirlpools in water.

Military men have long observed with the naked eye small flocculent clouds that indicate the train of the ball and that have likewise been seen by Capt. Mach. These flocks, which appear to be due to a condensation of aqueous vapor, are produced under circumstances that it would be impossible to define. They sometimes appear when the weather is dry, and sometimes too when it is damp. In most cases no perceptible traces of them are observed, even with the telescope, and under the most favorable conditions of observation.—*La Nature.*

THE OMNI-TELEMETER.

THIS instrument was designed by the late Mr. William Dredge to give distances by means of triangulation without calculation, either by using inside or outside angle. Many plans have been adopted for military and ordinary surveying; but no instrument we know of embraces so many alternative, and, at the same time, simple, methods of use as this does. It is an advance on the "Simplex Range Finder and Optical Square," and as it does not require an exact right angle at one end of the base to be laid out, it can be used very quickly; for by means of a compensating screw on the opposite side of the circular box to the micrometer screw, coincidence can be obtained between the direct and reflected objects, notwithstanding they are 5° or 8° removed from 90° (the right angle); in all, a latitude of 16° is thus obtained for choice of mark or end of base on which to make coincidence with the object. Where the ground on which a base can be laid out is not very limited, the outside angle of the triangle is measured by observing a distant natural object for a mark—such as a tree, rock, etc.—nearly at right angles to the objects to be measured. Then, on looking through the eyehole of instrument, or through the telescope shown in illustration, the compensating screw alluded to is turned until the mark and the object coincide by direct and reflected light. A distance of 50 yards (or some proportion of it) is then laid out in the same line as the mark, and at the exact spot at the end of the line, chain, or tape, when in alignment, the observer turns the micrometer screw until the object and mark are seen to correspond by reflected and direct vision. The number is then read off the index, and on reference to the table affixed to the instrument the range will be found in a column opposite. This may represent yards, meters, etc., according to the measurements used on the base, and includes ranges from 228 to 7,538 units. As any proportion of 50 can be used for the base, provided the same is also used on the range results, it follows that any distance from 30 yards up to any visible distance can be taken, provided the ground permits of the object being seen from both ends of the base (constricted or elongated, as the case may be).

In confined positions the inside angles are measured and distances obtained at sight by simply aligning a man or picket at the end of base with the object (seen either by direct vision or reflection). All that has to be done is to carefully set the instrument to its zeros, and look at the other end of base, then turn the micrometer screw until coincidence is obtained; without taking any notice of this reading, the compensating screw is now turned until pointer seen in figure is immediately over the line around micrometer head. The observer leaves a picket or man in exact position he occupied, and proceeds to the other end of base; there he looks at the object and turns the micrometer screw until he reflects the picket or man on the object. The number read off on the micrometer head will show on reference to the table fixed to base of instrument the exact range. The clever part of this arrangement is the mechanical correction or automatic addition of the two angles, so that not only can two angles, *neither* of which are right angles, be used, but only one reference to the index is necessary, and the distance of objects is obtained without calculation. One revolution of the micrometer head screw is equal to one degree (*i. e.*, by reflection two degrees), and as this is divided into 100 parts, a very close reading is obtained. Mr. Coles, of the Royal Geographical Society, author of "Hints to Travelers," has thoroughly tested this instrument, and speaks in high terms of it, and the certificate from Kew Observatory, which we have also seen, vouches for the scientific accuracy. Mr. J. H. Steward, optician, 406 Strand, London, is the maker and joint patentee of the instrument. The omni-telemeter will also give vertical heights and horizontal distances by using a fixed angle, or it will take ranges without measuring the base.—*Eng. Mechanic.*



THE OMNI-TELEMETER.

POTATO STARCH.

THE preparation of potato starch has long been an industry of importance, and it is for the sake of its starch that the potato is so widely used as a food. One of our highest English authorities gives 15 per cent. as the amount of starch present (75 per cent. being water), but this is as the mean of several analyses. German analyses of different varieties give a range up to 20, 22, and even 25 per cent., so that the actual starch value would thus appear to vary in different varieties. But it may be questioned whether the same variety may not differ according to season as much as varieties differ one from another. Although in recent years many important improvements have been made in the processes and the machinery used in starch preparation, only slight scientific attention has been given to the growth of potato crops. It is principally as a food that the potato is regarded, but to obtain the highest percentage of starch must be the chief aim of the cultivator, whether he is growing for the table or the manufactory.

Since the appearance of "Liebig's Agricultural Chemistry" in 1840, much chemical investigation has been directed to the cultivation of cereals, and now the most suitable conditions for their growth are fairly well known. The imperfect knowledge respecting potato growth is due to the fact that no chemist has made it a study. It is somewhat remarkable that, though there is at present so much activity among physiological chemists in studying the process of the formation of starch in the leaves of plants, in not a single case, till within the last few weeks, does the potato appear as the plant chosen for observation. With regard to plants generally, it has been recently established (contrary to old beliefs) that the carbon of the starch ($C_6H_{10}O_5$) in leaves comes from the carbonic acid of the air. The old belief was that it entered by the roots, dissolved in water. Allowing that the process of formation of starch in the leaves and the question of the part played by the chlorophyl cells are matters of purely scientific interest, the fact of its formation there cannot be overlooked by the practical cultivator. Varieties differ much in foliage, and the number of starch-forming leaves vary. If it be clearly established that the total leaf area of a plant has direct relation to the amount of starch a plant forms, then those who grow potatoes extensively for the market cannot neglect to pay attention to the character of foliage. The question has become more complicated through the results of two experiments recently made. One is that the amount of light sufficient to form the green coloring matter of leaves (chlorophyl) is not necessarily sufficient to form starch. The other is that light when it has once passed through chlorophyl has lost its power to form starch, so that those leaves which are shaded by others form very little, perhaps none. In connection with a plant cultivated solely for the sake of its starch these are important facts to know, and though the experiments were made on other plants, there is no good reason to doubt they are equally true with regard to the potato.

Within the last few weeks it has been found from analysis of potato plants themselves that there is no trace of starch in the stem. Starch and sugar are readily convertible, one into the other. It would appear, then, that the starch of the leaves is converted into sugar, and as such passes down the stem, and is then reconverted into starch in the tubers. What is the process of the formation of those starch granules which are such favorite objects for the microscope has not yet been studied, and hence there is no answer to the question, What is the cause of that condition popularly called "waxiness"?

The discussion that has been going on for so many years about "granulose" and "farinose" appears to be, for the present at least, drawing to an end with the agreement to call both "starch substances."

Boussingault, in 1836, studied the effects of temperature in relation to potato growth, and the effects of manures have been studied at Rothamstead, but starch formation has been a neglected subject. Now that attention is being given to it from a chemical and physiological point of view, hopes may be entertained that some scientific facts may be acquired and turned to practical use, for though the workers at present are few, others, seeing the importance of the subject, may take it up.—*Jour. Soc. Arts.*

THE ROYAL SOCIETY.

AMONG the subjects exhibited and illustrated at the conversazione on May 9 were the following:

Experiments on the Optical Demonstration of Electrical Stress.—Exhibited by Professor A. W. RUCKER, F.R.S., and Mr. C. V. BOYS, A.R.S.M.

These experiments are similar to those devised by Dr. Kerr, the arrangements being modified so as to render them suitable for exhibition in public.

Conductors of various forms are immersed in bisulphide of carbon and placed between crossed Nicol's prisms. When the conductors are oppositely electrified, the medium is thrown into a state of stress, and the light which had been extinguished by the analyzing prism is restored.

The various forms of conductors employed are:

Parallel cylinders, concentric cylinders, parallel planes, a plane and cylinder, and plates bent so as to represent a section of a Leyden jar.

Many of the phenomena exhibited by crystals in plane polarized light are imitated—*e. g.*, the black cross and the production of colors similar to those in Newton's rings. A bright field can be maintained by the introduction of a plate of selenite between the Nicols, in which case the electrical stress is indicated by change of color.

Large Electrical Influence Machine.—Exhibited by Mr. JAMES WIMSHURST.

It has 12 disks of 2 feet 6 inches in diameter; each disk carries 16 metal sectors. The machine is self-exciting in any condition of atmosphere. It shows large and perfect brush discharge at its terminals. With Leyden jars will give sparks 13⅝ inches in length.

Radio-Micrometer.—Exhibited by Mr. C. V. BOYS, A.R.S.M.

This is probably the most delicate instrument for measuring radiant heat yet made. It consists of a circuit made of antimony, bismuth, and copper hung by an exceedingly fine fiber of quartz in a strong magnetic field. A scale model of the circuit, twenty times the size or 8,000 times the weight, shows the construction of the suspended part of the instrument. The fiber, if magnified to the same extent, would still be finer than spun glass. The proportions of the several parts are those which have been found by calculation (confirmed by experiment) to give the greatest possible delicacy.

Experiments with Soap Bubbles.—Exhibited by Mr. C. V. BOYS, A.R.S.M.

These experiments are arranged to show chiefly the power of an air film to prevent two bubbles from coming into real contact. Thus, among other experiments, the outer of two bubbles may be pulled out until it squeezes the inner one into a long oval, but no real contact takes place. An inner bubble filled with gas will carry up an outer one to which are attached a wire ring and other things without really touching it at all. A bubble will roll down a spiral groove also made of soap film, or jump one or two steps at a time down a spiral staircase made of soap film, without touching the spiral film or being injured in the least.

Some of the experiments show the effects of diffusion, of vibration, of magnetism, or of electricity upon bubbles or groups of bubbles.

An Apparatus for Determining the Hardness of Metals or Other Substances.—Exhibited by Mr. THOMAS TURNER, A.R.S.M., F.C.S., F.I.C.

This apparatus is a modification of the sclerometer used in determining the hardness of minerals. A polished surface of the metal or other material to be tested is brought underneath a weighted diamond, which is moved in such a manner as to produce a visible line on the smooth surface. The weight in grms. necessary to produce a standard visible scratch is taken as a measure of the hardness of the material.

A Coulomb Meter.—Exhibited by Prof. GEORGE FORBES, F.R.S.

Consists essentially of a conductor of iron wire in the form of a spiral, or a double ring with cross wires. Above the conductor a set of vanes is pivoted. This consists of a circular disk of mica with a hole in the center in which is fixed a paper cone carrying at its apex a pinion with a concentric ruby cup. Round the circumference of the mica disk eight small cylinders of pith are fixed at equal distances, and eight vanes inclined at 45° to the mica disk are attached to the pith cylinders, these vanes being made of the thinnest mica. This set of vanes is supported by the ruby cup resting on a steel point fixed to the base of the instrument. The pinion engages with the first wheel of a train of wheelwork actuating the indexes, which show upon dials the number of revolutions made by the vanes.

The action of the instrument is very simple. The electric current passing through the iron conductor creates heat, which sets up a convection current in the air, and this causes the vanes to rotate about the vertical axis and drive the clockwork. The number of revolutions indicated on the dials is, through a considerable range of currents, an exact indication of the number of coulombs or ampere hours which have passed through the conductor. The friction of the ruby cup on the pivot determines the smallest current which can be accurately measured, and the friction of the clockwork is barely perceptible. The resistance of a meter to read from 1 ampere upward is 0·02 ohm.

The New Iridio-Platinum Incandescent Gas Burner (Lewis and Sellon's patents).—Exhibited by Messrs. JOHNSON, MATTHEY & Co.

Apparatus for the Isolation of the Element Fluorine.—Exhibited by Prof. T. E. THORPE, F.R.S.

(a) Apparatus for the preparation of anhydrous hydrofluoric acid by heating acid potassium fluoride.

(b) M. Moissan's apparatus for the electrolysis of hydrofluoric acid.

Apparatus for Measuring the Changes produced by Magnetization in the Dimensions of Rods and Rings of Iron and Other Metals.—Exhibited by Mr. SHELFORD BIDWELL, M.A., F.R.S.

The instrument exhibited is capable of measuring changes of length to a millionth of a millimeter or a twenty-five-millionth of an inch.

An *iron* rod when magnetized becomes (as is well known) at first slightly lengthened. But if the magnetizing force is sufficiently increased, it again contracts, and ultimately becomes actually shorter than when unmagnetized. A *cobalt* rod contracts under magnetization, reaching a minimum length in a field of about 500 C.G.S. units, beyond which point it becomes longer. A *nickel* rod also contracts; the limit of its contraction not having been reached with the greatest magnetizing forces yet used. *Bismuth* is slightly elongated in intense fields. See *Proc. Roy. Soc.*, vol. xliii. (1888), p. 406.

Experiments Illustrating Low-temperature Spectra in Connection with the Spectra of Meteorites.—Exhibited by Mr. J. NORMAN LOCKYER, F.R.S.

(1.) Spectra of Mg, Mn, Pb, Fe, Ba, etc., at the temperature of the oxy-coal-gas flame.

The brightest of the lines, bands, and flutings seen under these conditions are those seen in the spectra of uncondensed meteor swarms (nebulæ, comets, "stars," with bright line spectra, and bodies of Group II.).

The bright edge of the fluting at 500 in the spectrum of magnesium is coincident with the chief line in the nebula spectrum. Usually only the remnant of the fluting is seen, but on one occasion, at Greenwich, it was recorded as a fluting in the spectrum of the nebula in Orion.

The brightest manganese fluting is at wave length 558, and the second in intensity is at 586. The latter is seen as a dark band in all bodies of Group II., but the one at 558 is not seen in all of them. In these cases it is marked by the bright carbon fluting beginning at wave length 564, the second one remaining visible because there is no carbon fluting near it. It may be remarked that the second manganese fluting is the probable origin of the so-called D_3 line in the spectrum of γ Cassiopeiæ, the appearance of a bright line being due to contrast at the darkest edge of the fluting.

The line of manganese at 540 is seen in the spectra of most of the "stars" with bright lines.

Another case of masking is that of barium. The brightest band is at wave length 515, and the second at 525. In some of the bodies of Group II., only the second band is seen, the first one being masked by the bright carbon fluting at 517.

(2.) Photographs of spectra at the temperature of the oxy-coal-gas flame.

The spectra of Mg, Mn, Fe, Pb, Ba, Sr, Ca, Cr, Bi, Cd, and Al, with a comparison spectrum of air and calcium in each case.

(3.) Experiment showing the conditions of disappearance of the C and F lines from the spectrum of hydrogen.

The tube exhibited was prepared by putting a small chip of sodium in one of the open ends and sealing off behind it. The other end being connected with a Sprengel pump, the tube was exhausted and the sodium gently warmed. After further exhaustion the pump was stopped, and under these conditions C and F were visible. The sodium being again heated, C and F gradually dimmed, and the structural spectrum of hydrogen appeared, the color changing from red to blue. When C and F had disappeared, the tube was sealed off. Under present conditions C and F are not seen in the spark without jar, but on putting the jar in the circuit they make their appearance. The condition for the absence of C and F is that of maximum conductivity. The fact that the structure spectrum can be derived from the ordinary spectrum, and *vice versa*, proves it to be a true spectrum of hydrogen, and not an impurity spectrum.

The structure spectrum is of interest in connection with the meteoric hypothesis, inasmuch as some of the lines are apparently coincident with lines in the spectra of some of the "stars" with bright lines. But since some of the strongest lines are absent from the spectrum of the "stars," the coincidences are very probably accidental.

(4.) Map of meteorite spectra at the temperature of the oxy-coal-gas flame.

The spectra of the flames of 16 meteorites have been observed, and on the map they are arranged in order, beginning with the irons and passing gradually to the most stony ones. Only lines of Fe, Mn, Na, K, Li, and Cu, and two flutings, one of iron and one of manganese, are seen.

(5.) Photographs of some of the meteorite flames are also exhibited, but at present the series is incomplete.

(6.) Photograph of a composite spectrum of meteorites compared with the solar spectrum.

Two pieces of the Nejed meteorite were bound with wire to the two carbons of an arc lamp, so that they served as poles. A mixture of meteorites, both iron and stony, was then made, and a small quantity put on the lower pole. The plate being exposed, the current was made to pass and the spectrum photographed. One-half of the slit was exposed to the meteorites and the other half to the sun.

Exhibited by Mr. W. C. ROBERTS-AUSTEN, F.R.S.:

Specimens of gold showing the effect of small quantities of impurity on the fracture of the metal.

Exhibited by the WOODHOUSE & RAWSON ELECTRIC SUPPLY COMPANY:

Vernon Harcourt's New Pentane Standard Lamp.

New Carbon Microphone Button.

Samples of "Adamantine" Carbon.

New Chemical "Pole Indicator."

Holophotometer for measuring the intensity of a light all round.

Exhibited by the EDISON & SWAN UNITED ELECTRIC LIGHT COMPANY:

Edison & Swan Company's Safety Lamp for Miners.

The lamp consists of a storage battery of four cells inclosed in a strong teak box turned out of the solid and strengthened with metal bands; and a small incandescent lamp mounted on the side of the case, protected by a strong glass cover. The case is fitted with a hinged lid secured by a crossbar fastened with a safety nut, and having a swivel handle.

The full size of the lamp is 7 inches by 4¼ inches, and the weight of the whole ready for use is about 7 lb.

(1.) Lamp ready for use.

(2.) Battery withdrawn from the case, consisting of four cells or accumulators joined in series, the terminals being brought down the sides of the battery in the form of two contact plates which, when the battery is put into the case, make contact with two corresponding plates inside the case, and so convey the current from the battery to the small incandescent lamp.

(3.) Frame in which the battery stands while being charged with current from the dynamo.

(4.) Hook for lifting out the battery.

(5.) Key for unlocking the nut.

(6.) Screwdriver used to remove the glass cover when replacing the incandescent lamp.

(7.) Pipette for filling the battery with acid.

(8.) Lamp with fire damp indicator attached.

Exhibited by the SCHANSCHIEFF ELECTRIC LIGHT & POWER COMPANY:

Miners' Electric Safety Lamps.

(1.) A three-cell lamp capable of giving 1½ candle power for nine hours. Each cell contains 5 fluid oz. of solution and consumes ¾ lb. of zinc in forty-eight hours. The light is more than four times more powerful than that of the Clanny oil lamp, and its working cost is ⅝d. per shift of nine hours, or 3¾d. per week. The weight when fully charged is about 3½ lb. The elements consist of carbon and zinc, and the excitant is a mercurial solution of Mr. Schanschieff's invention.

(2 and 3.) Four-cell batteries, one round and one square. Each cell contains 5 fluid oz. of solution, and at a cost of 1d. furnishes a light of nearly 2 candle power for nine hours. The weight when fully charged is 4½ lb.

(4.) A four-cell reversible battery, *i. e.*, put in or out of action by reversing it. The charge consists of 24 oz. of solution, and giving a light of 2 candle power, will burn from ten to twelve hours at a cost of 1d.

The batteries can be used for many purposes other than mining lamps, viz., for microscopical purposes, house lighting, photography, diving, railway lighting, gun firing, gas works, etc.—*Chem. News.*

SCIENCE AND REVELATION.*

ON the present anniversary, which is the conclusion of my first year of office as president of this Institute, I propose to address a few words to you bearing on the object of the Institute and on the spirit in which, as I conceive, that object is best carried out.

The highest aim of physical science is, as far as may be possible, to refer observed phenomena to their proximate causes. I by no means say that this is the immediate, or even necessarily the ultimate, object of every physical investigation. Sometimes our object is to investigate facts, or to co-ordinate known facts, and endeavor to discover empirical laws. These are useful as far as they go, and *may* ultimately lead to the formation of theories which in the end so stand the test of what I may call cross examination by nature, that we become impressed with the conviction of their truth. Sometimes our object is the determination of numerical constants, with a view, it may be, to the practical application of science to the wants of life.

To illustrate what I am saying, allow me to refer to a very familiar example. From the earliest ages men must have observed the heavenly bodies. The great bulk of those brilliant points with which at night the sky is spangled when clouds permit of their being seen, retain the same relative positions night after night and year after year. But a few among them are seen to change their places relatively to the rest and to one another.

The fact of this change is embodied in the very name, planet, by which these bodies are designated. I shall say nothing here about the establishment of the Copernican system: I shall assume that as known and admitted. The careful observations of astronomers on the apparent places, from time to time, of these wandering bodies among the fixed stars supplied us, in the first instance, with a wide basis of isolated facts. After a vast amount of labor, Kepler at last succeeded in discovering the three famous laws which go by his name. Here, then, we have the second stage; the vast assemblage of isolated facts are co-ordinated, and embraced in a few simple laws. As yet, however, we cannot say that the idea of causation has entered in. But now Newton arises, and shows that the very same property of matter which causes an apple to fall to the earth, which causes our own bodies to press on the earth on which we stand, suffices to account for those laws which Kepler discovered—nay, more, those laws themselves are only very approximately true; and, when we consider the places of the planets, at times separated by a considerable interval, we are obliged to suppose that the elements of their orbits have slowly undergone slight changes.

But the simple law of universal gravitation, combined, of course, with the laws of motion, not only leads to Kepler's laws as a very close approximation to the actual motions, but also accounts for those slight changes which have just been mentioned as necessary to make Kepler's laws fit observation exactly. We are inevitably led to regard the attraction of gravitation as the *cause* which keeps the planets in their orbits.

But it may be said, What is the difference in the two cases? Is not the law of gravitation merely a simpler mode of expressing the observed facts of the planetary motions just like the somewhat less simple laws of Kepler? What right have we to introduce the idea of causation in the one case more than in the other?

The answer to this appears to be that in the one case, that of Kepler's laws, supposing them to be true, we have merely a statement of what, on that supposition, would be a fact regarding the motions of the planets, whereas in the other case the observed motions are referred to a property of matter of the operation of which in other and perfectly different phenomena we have independent evidence.

I have purposely omitted to mention the important difference between the two cases which lies in the circumstance that Kepler's laws require correction to make them applicable to long intervals of time, whereas the law of gravitation shows no sign of failure; because, even if the former had been perfectly exact, however long the interval of time to which they were applied, I doubt if they would have carried with them the idea of causation.

To take another simple illustration. Let us think of the propulsion of a bullet in an air gun. We speak of the motion of the bullet as being *caused* by the elasticity of the compressed air. And the idea of causation comes in because we refer this particular instance of motion to a property of gas, of the existence and operation of which we have evidence in perfectly independent phenomena.

It is thus that in scientific investigation we endeavor to ascend from observed phenomena to their proximate causes; but when we have arrived at these, the question presents itself, Can we in a similar manner regard these causes in turn as themselves the consequences of some cause stretching still further back in the chain of causation? If the motion of the bullet in an air gun be caused by the elasticity of the compressed air, can we account for the elasticity of a gas? If the retention of the planets in their orbits be due to the attraction of gravitation, can we explain how it is that two material bodies should attract one another across the intervening space?

Till a time well on in the present century, we could only take the elasticity of gases as a fact, and deduce the consequences which flow from it. But the researches of Joule and Clausius and Maxwell and Crookes and others have accumulated so much evidence in favor of the general truth of the kinetic theory of gases, that we are now disposed not to rest in the elasticity of gases as an ultimate property beyond which we cannot go, but to regard it as itself a consequence of the molecular constitution of bodies and of the motions and mutual collisions of the ultimate molecules of a gas. Respecting the attraction of gravitation, we have not at present made a similar advance. Speculations, indeed, have not been wanting on the part of those who have endeavored to account for it. But none of these so fits into the known phenomena of nature as to carry with it a conviction of its truth. Yet there is one indication that though we cannot at present explain the cause of gravitation, yet it *may* be explicable by what are called second causes. The mass of a body is measured by its inertia; and though we commonly think of a body of large mass as being heavy, and though we compare the masses of two bodies most easily and accurately through the intervention of weight, yet the idea of mass may be acquired, and means might easily be suggested by which the ratio of the masses of two bodies might be experimentally determined, without having recourse to gravitation at all. Now, according to the law of gravitation, the force with which a given body attracts another at a given distance is strictly proportional to the mass of the latter. If we suppose the attracting body to be the earth, and the attracted bodies to be in one case a brass weight and in the other a piece of marble, it follows that if they make equilibrium when placed in the pans of a true balance—I make abstraction of the effect of the buoyancy of the air—their masses are strictly equal, and accordingly, that weight is a true measure of mass. But there is no reason *a priori*, so far as with our present knowledge we can see, why this should be so. We know that if the bodies in the scale pans were formed one of brass and the other of iron, and there were a magnet concealed under the table on which the operator placed his balance, the masses would not be equal when there was equilibrium. But that the law is true, and that, accordingly, weight is a true measure of mass, follows with the highest probability from the third of Kepler's laws, and was proved experimentally by Newton, by experiments with pendulums. Newton's experiment has since been repeated by Bessel, with all the refinements of modern appliances, with the result that, so far as the most exact experiments enable us to decide, the law is strictly true. This is perhaps the only instance, as Sir William Thomson remarked to me in conversation, in which there is an exact agreement between two quantities, and yet we are unable to give any reason why they should agree. That such is the case holds out some prospect of scientific men being able some day to explain gravitation itself—that is, to explain it as the result of some still higher law.

Such is the nature of our progress in scientific investigation. We collect facts; we endeavor to co-ordinate them and ascertain the laws which bind them together; we endeavor to refer these laws to their proximate causes, and to proceed step by step upward in the chain of causation. Presently we arrive at a stage at which, even after long trial, we do not see our way to going further. Yet we are not able to demonstrate that further progress in the same direction—that is, along the chain of secondary causation—is impossible. Science conducts us to a void which she cannot fill.

It is on other grounds that we are led to believe in a being who is the author of nature. A conclusion so important to mankind in general is not left to be established as the result of investigations which few have the leisure and ability to carry out. Doubtless, where it is accepted, the study of science enlarges our ideas respecting the greatness of that being, and tends to keep in check notions of too anthropomorphic a character which we might form concerning him. Still, the subject matter of scientific study is not, at least directly, theistic, and there have not been wanting a few instances of eminent scientists who not merely rejected Christianity, but apparently did not even believe in the being of a God.

The religious man, on the other hand, who knows little or nothing of science, is in the habit of contemplating the order of nature not merely as the work of God, but in very great measure as his *direct* work. Of course, the concerns of every day life present innumerable instances of the sequence of cause and effect; and few are now so ignorant of the very elements of science as not to allow that the sequence of day and night, of summer and winter, is proximately due to the rotation of the earth about its axis and the oblique position of that axis with reference to the plane of the earth's orbit. But when we get beyond the region of what is familiarly known, still more when we get outside the limits of well ascertained

* Presidential address delivered by Prof. Stokes, P.R.S., at the annual meeting of the Victoria Institute, on Tuesday, July 19, 1887.—*Nature.*

scientific conclusions, and enter a region which is still debatable ground, where men of science are attempting to push forward, and are framing hypotheses with a view to the ultimate establishment of a theory in case those hypotheses should stand the test of thorough examination—when, I say, we get into this region, a man such as I have supposed may feel as if the scientists who were attempting to explore it were treading on holy ground; he may mentally charge them with irreverence; perhaps he may openly speak of them in a manner which implies that he attributes to them an intention to oppose revealed religion.

To take a particular example. I can imagine that a man such as I have supposed may have always been in the habit of regarding each one of the thousands and tens of thousands of species into which naturalists have divided the animal and vegetable kingdoms as having originated in an independent creative act; that the supposition may have become entwined among his religious beliefs. Such a man would be apprehensive of any attempt to introduce second causes in explanation of the observed fact of the great multiplicity of species.

Akin to the feeling which I have attempted to describe is another, against which we must be on our guard. The religious man is strongly impressed with the truth of certain things which lie outside the discoveries of reason or the investigations of science, and which bear on the whole conduct of his life here and on his hopes regarding a life hereafter. He believes these truths to be divine, and, accordingly, that no legitimate deduction of human reason is liable to come in conflict with them. But the precise mode in which a conviction of the truth of these things was arrived at depends, to a considerable extent, on each man's idiosyncrasy. His natural bent of mind, his early training, his later associations, have all a good deal to do with it. Divine truth is one thing; our own apprehension of it, and the steps by which in our own minds it has been arrived at, are another. These are liable to human imperfection, and we may not attribute to them the infallibility which belongs to that which is divine. We are not to confound the scaffolding with the building; nor, if we are anxious for the safety of the edifice, need we therefore fear that, if the scaffolding were tampered with, the whole might come tumbling down, nor should we regard as a dynamiter a fellow workman who would remove a pole or two.

That truth must be self-consistent, come from where it may, is an axiom which nobody would dispute; the only question can be, What is truth? Now, there are truths which we know by intuition, such as the axioms of mathematics; and there are others, again, which, though we do not perceive them by intuition, yet demonstrably follow from what we do so perceive; such, for example, are the propositions of mathematics. Then there are other conclusions which we accept as the result of the application of our reason to a study of nature. Here the evidence is not demonstrative, and the conclusion may have all degrees of support, from such overwhelming evidence as that on which we accept universal gravitation to what hardly raises the conclusion above the rank of a conjecture. On the other hand, there are conclusions which we accept on totally different grounds; namely, because we think that they have been revealed. Why we accept a revelation at all, is a very wide question which I cannot here enter into. That we do accept it is implied in the membership of this Institute. But, granting the acceptance of revelation, the question remains, What and how much is involved in revelation? That is a question respecting which there are differences of opinion among those who frankly accept a revelation, and with it the supernatural.

Now, the primary object of the establishment of the Victoria Institute was to examine the questions as to which there was a *prima facie* appearance of conflict between the conclusions of science and the teachings of revelation. In order that such examination may be usefully carried out, it must be undertaken in a thoroughly impartial spirit, with a readiness honestly to follow truth wherever it may lead. It will not do to assume that the immunity from error which belongs to the divine belongs also to our apprehension of what constitutes the divine, and that therefore, if a conflict there be, the error must be on the side of science. It is true that many statements which are really little more than scientific conjectures are represented, at least by those who take their science at second or third hand, as if they were the well established conclusions of science. But it is true also that the progress of science has corrected the assertions of a crude theology. We are disposed nowadays to smile at the idea of any opposition between the Copernican system and the teaching of revelation; but we need not go back to the days of the persecution of Galileo to find an example of a well supported scientific conclusion having met with a similar opposition, issuing in a similar result.

To gauge thoroughly the amount of evidence on which an asserted scientific conclusion rests, one ought to be well acquainted with the branch of science to which it relates. Still, one can get a fair general notion of the evidence by an amount of reading which is by no means prohibitive, or by conversing with those who have made that branch a special study. It may be that the impression thus left on the mind will be that the votaries of science, carried away by an excess of zeal in the attempt to discover the causes of natural phenomena, have really, though honestly, overestimated the evidence. It may be, on the other hand, that the inquirer will perceive the evidence to be weighty and substantial, in which case it behooves him to reconsider the supposition with which he started, that the conclusion was opposed to the teaching of revelation.

One should always bear in mind the great responsibility one incurs, and the mischief one may do, by representing as bound up with revelation that which really forms no part of it. Being by hypothesis no part of it, but only erroneously tacked on to it, it may be false, and being false, it may be in opposition to a conclusion supported by the weightiest evidence, it matters not of what kind, but say scientific. What, then, will be the effect of the error committed by the upholder of revelation? The educated man of science may see through the fallacy; but will it not put a weapon into the hands of the infidel lecturer wherewith to attack revealed religion?

But whether we can agree or cannot agree with the conclusions at which the scientific investigator may have arrived, let us, above all things, beware of imputing evil motives to him; of charging him with adopting his conclusions for the purpose of opposing what is revealed. Scientific investigation is eminently truthful. The investigator may be wrong, but it does not follow that he is other than truth loving. If on some subjects which we deem of the highest importance he does not agree with us—and yet it may be he agrees with us more than we suppose—let us, remembering our own imperfections, both of understanding and of practice, bear in mind that caution of the Apostle: "Who art thou that judgest another man's servant? To his own master he standeth or falleth."

FRENCH SHADOWS.

MR. CARAN D'ACHE, a young artist, has recently got up, at the Theater d'Application, at Paris, a special representation of Chinese shadows, which were devised by him, and are so superior to anything that has previously been done in this line that he has been able to call them "French shadows," in order to distinguish them from similar productions.

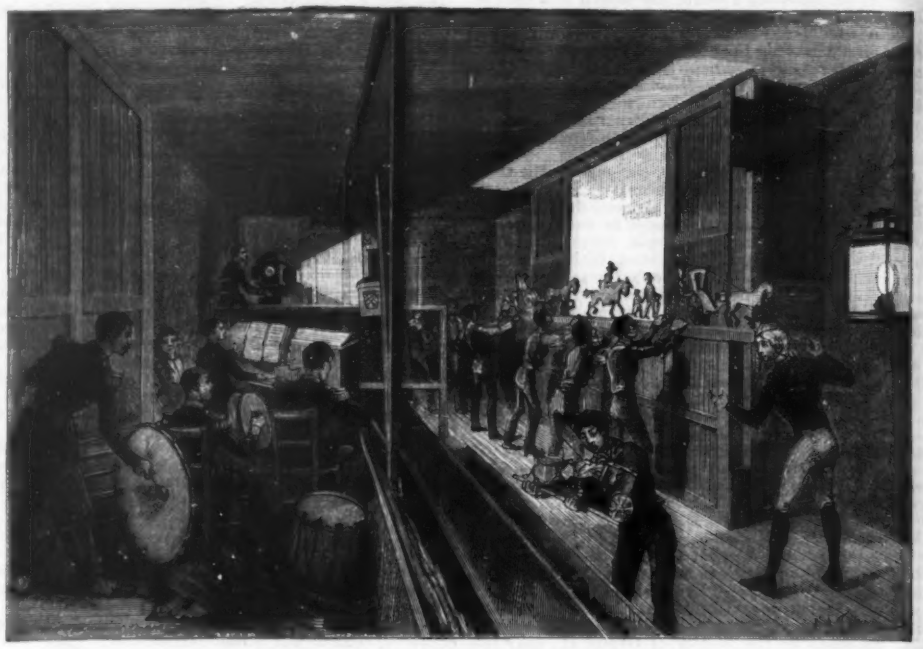
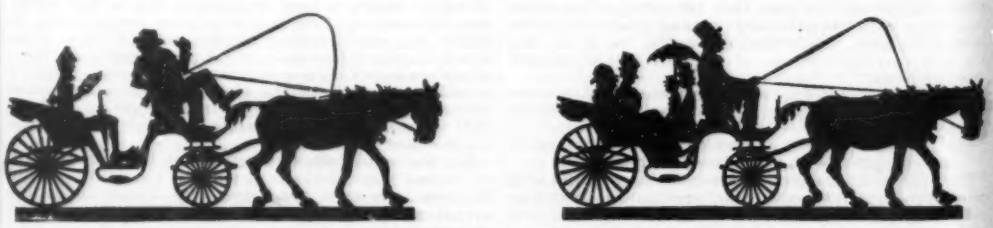


FIG. 1.—FRENCH SHADOWS.

Mr. D'Ache takes pleasure in representing the military scenes of the first republic and first empire. He projects upon the screen an entire army, wherein we see the Emperor with his staff at different distances amid the ranks. The defiling of the troops is astonishing, and one would think that he was present at a genuine review. A "Vision in the Steppes" is another series of pictures that represent the advent of the Russian army. The shadows entitled the "Return from the Woods" form a masterpiece as a whole, and the figures are so skillfully cut that the celebrities of the day who are passing in the Avenue des Acacias can be recognized. Two amusing specimens of this part of the representation are given in Figs. 2 and 3. These reproductions are much reduced, the real height of the figures being about eighteen inches.

We were not content to remain in the body of the theater to witness the shadows, but requested Mr. D'Ache to admit us to his side scenes for the sake of our readers, and to initiate us into the processes of actuating his figures; for, aside from the artistic aspect, there is here a very interesting application of physics.

The silhouettes, after being composed and drawn, are cut out of sheet zinc, which gives them much rigidity. The cutting is a very delicate operation and requires great accuracy. Some figures, such as those of cavalrymen, hussars, and dragoons of the grand army, have apertures in certain parts, and behind these is pasted colored transparent paper. In this way, the black shadows that move along the screen have certain parts in color, such as the plumes of the helmets and the horses' saddles.



FIGS. 2 AND 3.—FACSIMILES OF TWO SILHOUETTES.

A larger number of the zinc silhouettes act through mechanism. At a grand review, to the order "Carry arms," all the guns are seen to rise in unison. The silhouette is provided with a series of guns properly arranged and mounted upon a rod which is lowered or raised by the action of a lever.

Fig. 1 represents the back of Mr. D'Ache's theater. The screen being brilliantly illuminated by an oxyhydrogen lamp, and the light in the body of the theater being turned down, the silhouettes, in passing, project upon the screen a very strong shadow which the spectators perceive, but which is not visible from the side scenes. Each silhouette is taken from a large box by a man who places it in a groove at the bottom of the screen. Four or five operators suffice to keep the shadows succeeding one another without interruption. During the "Epopée" we witness great combats, the capture of redoubts, and terrible cannonading. Nothing is more amusing than the method of producing the effects of these epic contests. The cannons are provided with little fuses that an operator fires, and, at the same moment, the big drum of the orchestra imitates the noise of the cannonading, and a rattle of large size simulates the sound of the discharge of musketry. As for the smoke that the spectators perceive upon the screen, that is produced by the cigarette of one of the operators, who projects it at the desired place. The light of the shells is obtained by means of a wad of guncotton, lighted and properly projected.

Since the "Broken Bridge" and the Chinese shadows of the Seraphin Theater—never-to-be-forgotten recollections of our youth—we have seen nothing in this line that can be compared to Mr. D'Ache's French shadows. These, from the artistic standpoint of drawing and perspective effects, leave far behind them everything of the kind that has been produced up to the present.—*La Nature.*

QUARTZITES AND SILICEOUS CONCRETIONS.

By W. O. CROSBY, S.B.

THE preparation of this paper was first suggested to me by certain phenomena observed on Box Elder Creek, in the Black Hills of Dakota. The Potsdam beds in the canon of this stream, as at most points where they are exposed in the Black Hills, rest with a gentle inclination upon the nearly vertical Archæan slates, and are overlaid conformably by the Carboniferous limestones. The thickness of the Potsdam is about 250 feet, varying with the unevenly eroded Archæan surface upon which it was deposited, and the hollows of which were filled up by its basal beds. These basal members of the Potsdam are extremely variable when traced from place to place, changing rapidly from the prevailing normal sandstone, sometimes to strata that are highly calcareous or rich in glauconite, and again to conglomerate masses in which water-worn bowlders several feet in diameter are not uncommon. The basal sandstone is also often a firm quartzite.

There are many points in the northern hills where the Potsdam is not observed to rest directly upon the Archæan, but its lowest exposed strata are underlaid by intrusive sheets and laccolites of rhyolite and other acid lavas. The intrusive sheets vary greatly in thickness, and have often been injected at several different levels in the Potsdam, giving repeated alternations of igneous and sedimentary strata. There are also numerous dikes connecting the intrusive sheets. Around the laccolites the Potsdam beds are usually upturned, sometimes at sharp angles, forming concentric lines of outcrop encircling the igneous cones, by which they have been locally metamorphosed. In fact, the Potsdam in the vicinity of the igneous masses (laccolites, sheets or dikes), and when not distinctly argillaceous, calcareous, or glauconitic, is always a hard vitreous quartzite, and often highly mineralized, forming the contact ore deposits of the Ruby Basin and other districts.

The Potsdam sandstone of the Black Hills varies, as a sandstone, from an almost incoherent mass of siliceous grains, crumbling on exposure and easily crushed in the hand, to a tolerably dense and compact sandstone, which in weathering forms cliffs. The colors vary with the nature of the cementing material from a light gray to a dark-brownish red; and the lighter

kinds especially, sometimes seem to pass gradually into quartzite, the siliceous grains becoming embedded in a bright, glassy, siliceous cement.

As Newton has so clearly indicated,* "one of the most interesting points in the lithological structure of the Black Hills is the occurrence of beds of quartzite both at the base of the Potsdam and interstratified with its sandstones. Near Warren Peaks, Crow Peak, Terry Peak, and other igneous masses, quartzites have been formed from sandstones by the direct metamorphic action of the volcanic outbursts; and in other portions of the hills there are quartzites at the base of the formation which may possibly be the result of metamorphism accompanying the uplift of the hills. But in many places throughout the hills, beds of hard, compact quartzite are found interstratified with the ordinary soft sandstones. Some of these localities are far removed from any evident locus of igneous action; and, indeed, the change of particular strata into quartzite, while the overlying and underlying beds of sandstone are unaffected, is an occurrence which can scarcely be explained upon an igneous theory."

Similar conditions are not unknown elsewhere among the numerous Potsdam areas of the West, but nowhere, perhaps, are the facts so clearly exposed for study as in the Black Hills. The valley of Box Elder Creek presents, apparently, from this point of view, an exceptionally typical section of the Potsdam strata. The basal beds, as already indicated, are here a typical quartzite; while near the top of the formation a cliff of reddish sandstone, thirty feet in height, exposes numerous intercalated strata of hard, glossy quartzite, from six inches to several feet in thickness. It is also plain that some of the exposures of the Potsdam beds, from which the Carboniferous limestone has been removed by erosion, often owe their preservation to a thin but intensely hard sheet of quartzite.

Besides the continuous layers of interbedded quartzite, there are numerous discontinuous masses, one to several inches in thickness, and having the form of very thin, sharp-edged lenses of highly glassy quartzite scattered through the granular and almost friable sandstone. These conform with the bedding of the sandstone, and are almost as sharply defined as the nodules of chert in limestone. In their smallest developments the quartzite lenses are minute flecks and shreds of the vitreous cementing silica, enveloping only a few grains of sand. Except that the cement is mainly vitreous instead of chalcedonic, and envelops the original water-worn grains of quartz instead of excluding them, it is strongly suggestive of the siliceous segregations of calcareous strata. The thin films or crusts of quartzite, described by Irving and Van Hise† as occurring on the weathered surfaces of the Potsdam and St. Peter's sandstones of Wisconsin, were distinctly observed on Box Elder Creek.

In discussing the probable origin of the interbedded quartzites, Newton rightly emphasizes their isolation by considerable thicknesses of entirely unaltered sandstone and shale. He clearly saw, as the following quotation shows, that this significant fact effectually bars out the usual igneous or hydrothermal hypothesis. "If only the basal member of the series assumed this character, it would be easy to suppose that there was some metamorphic action proceeding from below. But no such explanation will apply to the interstratified quartzites. If we suppose them to have been formed by igneous induration, even accompanied by heated waters, the unchanged condition of the intermediate and adjacent sandstones cannot be accounted for; and the uniformity of the quartzites in thickness, and their marked separation from the associated common sandstone, are equally difficult to understand. The quartzitic layers are sometimes separated by over one hundred feet of unchanged sandstone from the underlying schists, while even the basal conglomerate has not been metamorphosed in the least particular. In sections of the Potsdam, also, where the relations to the underlying schists are the same, and where there is no evidence of greater igneous action in the one case than in the other, the sandstones of one exposure will contain numerous beds of quartzite and those of another none."‡

Professor Newton then goes one important step further, and plainly indicates what appears to be the only entirely satisfactory explanation of the interbedded quartzite, as follows: It is due to the gradual segregation, through the ordinary slight changes of temperature and pressure, of the soluble silica which, in the form of diatoms, sponge spicules, etc., was an original constituent of the formation, the layers of siliceous cement growing somewhat after the manner of layers and nodules of flint and chert. These microscopic siliceous organisms occur most abundantly in chalk and other forms of limestone; and Newton's view of the origin of the interbedded quartzite derives additional support from the fact that the Potsdam sandstone of the Black Hills is often distinctly calcareous. There appears to be no good reason for regarding the basal quartzite as essentially different in either character or origin from the interbedded quartzite. It has been convenient to refer to them separately, simply because the evidence of a non-igneous origin is less conclusive for the basal than for the interbedded quartzite.

The Potsdam quartzites of the Black Hills thus fall naturally into two classes. (1) The quartzites associated with, and almost coextensive with, the igneous rocks. These may be regarded as representing the metamorphism of the sandstone by the thermal and alkaline waters accompanying and following the intrusion of the volcanic materials. The cementing silica has probably been derived partly from the original organic siliceous constituents of the sandstone, but very largely, also, from the decomposition of the volcanic rock itself. (2) The interbedded (and probably, also, the basal) quartzites occurring beyond the influence of the volcanic action, and in entirely undisturbed portions of the stratified series.

A limited microscopic study of these two types of quartzite shows some structural differences. In the contact or igneous quartzites, as in the old Archæan quartzites, which are such a prominent feature in the geology and topography of the hills, the grains are angular and fit accurately without visible interstices, the interstitial or cementing silica having, as has been so clearly shown by Irving, Van Hise,* and others, been deposited in optical or crystallographic continuity with the original grains of quartz, which are thus extended into accurately fitting and interlocking areas. Thin sections of the interbedded quartzite from Box Elder Creek, on the other hand, show rounded grains, essentially similar to those of the unaltered sandstone, and often coated with films of iron oxide, etc.; while the cementing silica, although partly in the form of minute, independently oriented crystalline grains, is chiefly chalcedonic or hyaline. It fills the interstices between the grains as water would, and is not crystallographically continuous with them. Irving and Van Hise have figured sections not unlike those afforded by the quartzites of Box Elder Creek.† The more extended observations of Caswell,‡ however, show that the interbedded and basal quartzites are usually, like the contact or metamorphic quartzites, cemented by vitreous silica in the form of secondary enlargements of the original grains, each enlarged grain being, but for the inclosed foreign matter, optically uniform, angular, and accurately interlocking with the adjacent grains.

That the segregation of the original organic and amorphous silica, under the normal conditions of an undisturbed sedimentary series, may yield a highly vitreous or crystalline form of quartz, is proved not only by the observations of Irving and Van Hise on the Potsdam and St. Peter's sandstones of Wisconsin, in which there seems to be no other sufficient source of soluble silica, but also, and more clearly, by the abundant and perfect crystallizations of quartz in flint, chert, geodes, and other siliceous segregations. Nodules and layers of chert not only inclose crystalline druses, but the chert itself sometimes passes insensibly into granular, vitreous quartz, not easily distinguished from typical quartzite. Such cherts are described by Irving and Van Hise, and have been observed by the writer in the Silurian limestones of East Tennessee.

That the twofold origin of the cementing silica indicated by the modes of occurrence of the Potsdam quartzites of the Black Hills is a general fact there can be but little doubt. The abundant deposition, in the form of mineral veins and siliceous tufa, by thermal and alkaline waters, of silica which must have been derived from the decomposition of alkaline silicates, shows that in the neighborhood of eruptive masses, and generally at considerable depths, silica having this hydrothermal or purely chemical origin must often exist abundantly in the waters percolating through the arenaceous rocks. On the other hand, it is a well established fact that microscopic siliceous organisms—diatoms, radiolaria, etc.—exist in all parts of the sea, and in nearly all natural waters; and consequently they must form a part of nearly every kind of sediment. The supposition, therefore, seems warranted that, even in the arenaceous rocks, this minutely divided, soluble, organic silica must sometimes be sufficiently abundant to explain, by its solution and redeposition, their conversion into quartzite. As already stated, this explanation of the siliceous induration of sandstones appears to be peculiarly applicable to interbedded and isolated quartzites in undisturbed formations, remote from volcanic sources; and we may suppose that in sandstones which have not experienced the quartzite alteration the organic silica occurs so sparingly as not to form a saturated solution with the interstitial water, except near the surface, where evaporation lends its aid to the formation of the quartzite crusts described by Irving and Van Hise.

It will, I think, be generally conceded that this principle of classification according to the source of the silica may be properly extended from the cement of the quartzite to the various more concrete forms of segregated silica, such as the nodules, geodes, veins, druses, incrustations, etc., of flint, chert, chalcedony, agate, jasper, and the many other and more crystalline forms of quartz. When these are associated with eruptive or metamorphic rocks, and more generally, when they occur under conditions which indicate that the silica has been derived directly from the decomposition of silicates by thermal or acidulated waters, as in the case of the great majority of the veins, pockets, and incrustations of crystalline quartz, chalcedony, agate, jasper, etc., they are evidently connected in origin with the contact of metamorphic quartzites; while the nodules, geodes, etc., of flint, chert, and other kinds of silica observed in unaltered sediments, and especially in calcareous strata, are clearly related in origin to the interbedded quartzites.

It is not my purpose to discuss any further at this time the origin and relations of the contact or metamorphic quartzites, or of what may be called the purely chemical segregations of silica. Nor does it appear necessary to my main object to consider in detail the mode of formation of the segregated forms of silica observed in calcareous and other undisturbed sedimentary strata. Few of the minor problems of geology have received more attention at the hands of both geologists and mineralogists than the origin of the nodules and other forms of flint, chert, etc.; and it would be sufficient, so far as the relations of these segregations to the interbedded quartzites are concerned, to simply follow Geikie and other standard authors in attributing them to the solution and redeposition of the widely and abundantly distributed organic silica. A still recent contribution to this subject by Prof. W. J. Sollas§ is, however, so able and comprehensive, that we may perhaps profitably digress long enough to notice some of his more important conclusions and to follow up one or two suggestions to which they give rise.

The investigations of Professor Sollas have led him to regard the organic origin of the silica as an almost self-evident truth. The ready solubility of the siliceous organisms under natural conditions has been placed beyond reasonable doubt by numberless observations. Professor Sollas considers that we have still much to learn concerning the precise nature of the solvent. This is probably not always the same; and he makes the fertile suggestion that, while the conditions must often be favorable for the action of the humic acids and the albuminoid or glairy substances to which Julien attaches so much importance, it is probable that the organisms are often dissolved by the water alone, in the depths of the sea and in deeply buried sediments, where its solvent power is augmented by pressure.

In attributing the solution of the siliceous organisms and the redeposition of the silica to the slight oscillations of the chemical and physical conditions which must always be in progress, we are not in effect saying that the same portion of silica may be dissolved and redeposited many times in succession. Professor Sollas very properly emphasizes the plain fact that the silica which passes into solution is a very different thing from that which has passed out of solution. He calls the one *organic*, and the other *mineral* silica. The two forms are strongly contrasted in their solubilities, as well as in other chemical and physical characters; and hence segregation in this case means a solution of soluble organic silica and a deposition of insoluble mineral silica, and not a solution and deposition of the same kind of silica. In this connection he points out that the dissolved silica is deposited not only in the relatively insoluble forms of flint, chert, chalcedony, etc., but also in the almost absolutely insoluble form of crystalline quartz, as in geodes, etc., and in the perfect microscopic crystals disseminated in vast numbers through various forms of limestone. These microscopic crystals undoubtedly represent the independently oriented crystallizations of the cementing silica in quartzites.

One of the most important and interesting facts observed in connection with the siliceous segregations in sedimentary rocks is the very common occurrence of the segregated silica as a pseudomorph after calcium carbonate. The power of a dilute solution of colloid silica to replace calcium carbonate has been experimentally demonstrated by Prof. A. C. Church,* who has actually converted a coral into silica by this means. The ordinary solid nodules of flint and chert present a fairly clear case of this pseudomorphism, since we can rarely doubt that room has been made for the segregating silica by a concomitant solution of the embedding chalk or limestone. The evidence is much stronger, however, with silicified fossils; and the abundance in many limestones of shells, crinoids, corals, etc., which have been replaced by silica shows that calcium carbonate which still retains the organic form and structure is peculiarly liable to this replacement. It is doubtful if the substitution is usually so perfect, so nearly molecule for molecule, as in silicified wood. This is especially obvious in the geodes and similar forms, in which the silica only partially fills the space which must have been previously occupied by calcium carbonate. It is plain in such cases that the solution of the calcium carbonate proceeded more rapidly than if it did not entirely precede the deposition of the silica in the solid form. There could scarcely be a more instructive illustration than is afforded by the chalcedonized coral occurring in the Tertiary beds of Tampa Bay, Florida.

These interesting specimens, as all mineralogists know, are usually thin, hollow shells or geodes of translucent chalcedony, which are generally handsomely botryoidal, although occasionally finely crystalline or drusy, on the inner surface, while preserving the form of the coral very perfectly externally. As the inner, botryoidal surface suggests, the chalcedony has been deposited in layers parallel with the uneven exterior; and it is itself devoid of organic structure. The history of these geodes, which are externally but silicified casts of the corals, has evidently been something like this: The masses of coral, after becoming embedded in a stratum of marl, were completely removed by solution before the deposition of silica in the solid form began in the moulds thus formed. Accepting the view of Professor Sollas that the silica has been an active and necessary agent in bringing about the solution of the coral, we can scarcely escape the conclusion that the segregation of the silica was contemporaneous with the process of solution. This involves the further conclusion that during the solution of the coral the solution of the associated siliceous organisms was also taking place; and this dissolved silica was steadily accumulating, probably in a pectous or gelatinous condition, in the moulds left by the coral. Subsequently the silica, commencing externally, gradually passed from the pectous to the solid state, the last portions to solidify forming the inner surface of the geode, and very often assuming a crystalline form.

We have here, perhaps, a glimpse, at least, of the secret of the geode; and can almost grasp the explanation of the fact that some siliceous segregations are solid and others hollow. Nodules of flint and chert, and the ordinary geodes of limestone strata, alike represent the gradual replacement of gobular masses of limestone or chalk by equivalent portions of pectous silica. The main point of difference is, that in the solid segregations the silica passed from the pectous to the solid form as fast as it accumulated, and the nodules grew from the center outward; while in the hollow segregations the solidification of the silica did not, for some undetermined cause, begin until the replacement was complete—*i. e.*, until all the available organic silica had been dissolved, concentrated through its tendency to replace calcium carbonate, and thus reduced to the pectous state, and the geodes, consequently, grew from the circumference inward.

A precisely similar contrast may be traced between the ordinary silicified fossils and the silicified coral of Tampa Bay; the replaced calcium carbonate being in both cases in the form of entire organisms instead of massive limestone (fragmental organisms), and the solidification of the replacing silica being contemporaneous in one case and subsequent in the other. The water with which the unbroken coralline geodes of Florida are often partially filled may, apparently, be usually regarded as the water that would necessarily be excluded and left behind during the passage of the silica from the pectous to the solid or crystalline state.

Returning now to the further consideration of the relations between these various form of siliceous concretions and the interbedded quartzite, and accepting the postulate that the cementing silica of the latter shares the organic origin of the segregating silica of the former, we have first to notice the normal distribution of the organic silica in different classes of sediments. Recent investigations have shown that such pelagic siliceous organisms as the Diatomaceæ and Radiolaria

* U. S. Geol. Survey, Report on the Geology and Resources of the Black Hills of Dakota, by Prof. Henry Newton, 1880, pp. 88, 89.

† U. S. Geol. Survey, Bulletin No. 8, 1884, by R. D. Irving and C. R. Van Hise.

‡ Geology and Resources of the Black Hills of Dakota, pp. 92, 93.

* U. S. Geol. Survey, Bulletin No. 8, 1884.

† Ibid., plate VI.

‡ Geology and Resources of the Black Hills of Dakota.

§ On the Flint Nodules of the Trimmingham Chalk, by Prof. W. J. Sollas, Annals Nat. Hist., 1880, pp. 384-395; 497-461.

* Chemical News, v., 95; Jour. Chem. Soc., xv., 107.

inhabit the surface waters of nearly all parts of the ocean.

On the death of the organisms, their tests or hard parts slowly sink through the still waters; and the examination of the various kinds of marine sediments now in process of formation has shown that this quiet rain of organic silica is falling upon the ocean floor in all latitudes, and alike in the deepest and the shallowest parts of the sea, over the marginal zones of rapid deposit, as well as over the abyssal areas where deposition is almost at a standstill.

The organic silica is naturally a much more conspicuous feature of the deep sea oozes and clays, which are accumulating with extreme slowness, than of the terrigenous sediments, which are being spread with comparative rapidity over the shallower and more marginal portions of the sea floor. If, for example, the time required for the deposition of one inch of pure organic silica would permit the accumulation of one foot of deep sea ooze and of one hundred feet of mechanical shore sediments, it is plain that while the inch of silica would form an appreciable and even important fraction of the former, it would be an entirely insignificant constituent of the latter, being diffused with inappreciable thinness through the great mass of land detritus.

We are justified, therefore, in concluding that the organic silica must in general form a rapidly increasing proportion of marine deposits as we pass from the coarse gravels and sands of the shore lines across the finer sands and clays of the marginal zone to the purely calcareous sediments, the organic oozes, and the red clay of the abyssal areas. Assuming a uniform distribution of the siliceous organisms along a line from the shore seaward, it is obvious that their conspicuousness will be inversely proportional to the rate of deposit of the associated sediments.

Subsequently to its deposition, the organic silica, as already indicated, passes largely into solution, and under favorable conditions is redeposited in a more insoluble form. We seem at liberty to suppose that the solution and segregation of the silica often follows closely upon its deposition; but in other cases it is certain that it remains undissolved for considerable periods of geological time. Thus, this important change has not yet occurred to any appreciable or important extent in the great bed of diatomaceous earth or tripolite which is such a prominent feature of the Miocene Tertiary of Virginia and Maryland.

The dissolved and redeposited silica takes the form of concretions, geodes, etc., or, when very abundant, of more or less continuous layers of flint, chalcedony, etc., in calcareous sediments, and of quartzite in arenaceous or mechanical siliceous sediments. The interbedded character of quartzites formed in this way, and the fact that they are often entirely wanting in extensive series of mechanical sediments covering wide areas, is readily explained, as already pointed out, by supposing that the original organic silica was insufficient to form a saturated solution with the interstitial waters.

Thus in the Appalachian region, where the coarse, mechanical, Paleozoic sediments have a vast thickness and volume, and were evidently deposited so rapidly that the organic silica could never have formed more than an infinitesimal fraction of the whole, interbedded quartzites occur but rarely if at all; while in other regions, like the Black Hills, the Rocky Mountains, Wisconsin, etc., the Paleozoic, and especially the Potsdam, sediments, although often arenaceous, afford evidence in their fineness, uniformity, frequently calcareous or glauconitic character, and in their distances from the ancient shore lines, or from any abundant source of detritus, that they have been formed so slowly that organic silica may be regarded as a prominent original feature; and the arenaceous beds often exhibit the quartzitic alteration due to the segregation of this soluble silica. The non-metamorphic or interbedded quartzites are thus an indication of slow deposition—of the formation of sandstones under physical conditions which, when life is more abundant, yield limestones.

The question arises at this point as to why the product of the segregation of the organic silica is chiefly quartzite in arenaceous sediments, and concretions of chert, etc., in calcareous sediments. The answer is, probably, to be found mainly in the selective action of the segregating silica—in its innate tendency to deposit upon particles or surfaces of its own nature. Remembering that the redeposited silica is insoluble quartz instead of soluble opal, and it will be seen that in an ordinary quartzose sandstone every grain of sand is of like nature with the segregating silica, and affords a favorable center or nucleus for its deposition. Hence, as Irving and Van Hise have shown, when the process of segregation is not too rapid, the secondary enlargement of the grains, in the attempt to reproduce the missing portions of the original crystals, is the natural result. The organic silica thus appears almost as completely dispersed after as before its segregation. We cannot, however, doubt that the interbedded layers of quartzite usually represent a considerable concentration of silica; and that the layers, like solid concretions, grow from the middle line outward, by drawing in silica from the overlying and underlying portions of the sandstone. In calcareous sediments, on the other hand, the really favorable centers of segregation must usually be few and remote. Consequently larger volumes of sediment, and of sediment much richer in soluble silica, are tributary to the individual centers; and isolated concretions and geodes of sensible or large size are gradually developed.—*Technology Quarterly.*

DR. VON LUSCHAN'S JOURNEY IN ASIA MINOR.

THE *American Naturalist* says: At a recent meeting of the Geographical Society of Berlin, Dr. Von Luschan spoke of his explorations in Asia Minor, undertaken chiefly with archæological aims. Dr. Luschan accompanied Otto Benndorf into Lycia in 1881, and afterward visited the tomb of Antiochus I., discovered by Otto Predestein in 1882. This is an immense tumulus on the right bank of the Euphrates, between Iskenderun and Bagdad, on the peak Nemrud Dagh (7,000 feet). The tumulus is flanked on the east and west by five gigantic figures of gods, sixteen to twenty-three feet high. At a distance of ten days' journey from the coast, the traveler along this route comes upon the ancient bridge over the Bojlam-Su, a single stone arch, sixty-five feet in height and 325 in length. It was built by Septimius Severus, Caracalla, and Geta, and is to-day in perfect preservation. Afterward Dr. Luschan took part in the expedition of Count Lanckorovski, the object of which was the archæological exploration of Cilicia and Pamphylia. In other later journeys Dr. Von Luschan turned his attention to the complicated ethnography of Asia Minor. The Turco-Mongolian anatomical type is not to be found among the so-called Turks of Asia Minor. The Mohammedans of the peninsula belong to three types, viz., Old Grecian, Armenian, and Semitic. The race which gave the religion and language was numerically too weak to influence, to any considerable extent, the physical nature of the conquered people.

The Greeks exhibit the same three types, the true Greek predominating along the west coast and on the islands. The Armenians are a compact and homogeneous people, anatomically allied to the Tachkadschy or Alleor of Lycia, the Ansarieh or Fellach of S. E. Asia Minor and N. Syria, and the Kizilbash and Tezyde of Upper Mesopotamia and Kurdistan. The Turukes are genuine nomads, traditionally from the Hindoo Kush. Turcomans and Kurds also occur, besides Bulgarians, Arnauts, Arabs, gypsies, Europeans, and negroes, all of whom have immigrated in comparatively modern times.

THE FRENCH ASSOCIATION IN ALGERIA.

THE excursions that occurred during the meeting held at Oran by the French Association for the Advancement of Sciences were of peculiar interest. To speak of those only that took place after the meeting, we may mention the first one, which permitted of a visit to the interesting iron mines of Beni-Saf, Tlemcen, so picturesque as to its situation, and Sidi-Bel-Abbés, which is of recent founding, and has already acquired considerable importance. A second excursion took a southerly direction, and, crossing the high plateaux, reached Aïn-Sefra, and permitted of visiting Kreider, Saïda, and Mascara.

It was but natural that the principal excursions should be made in the province of Oran; but it had been decided in addition that one excursion should be made in the province of Constantine, with Tougourt as the objective point. It was a question of studying *in situ* the French colonization in the desert, and it was only in the Oued Rir' that it was possible to meet with oases of French creation. There was here an important question which justified the programme adopted. The number of persons that could take part in this excursion was strictly limited, and it was possible, by hurrying, to follow one of the principal excursions before this one started. It was desired, through such conditions, to prevent these from being neglected in favor of that of Tougourt.

We should add that many members of the association traversed our colony more or less completely, passing over to Algiers, visiting Kabylie, going to Constantine, Bougie, Bône, and Biskra, and pushing forward as far as to Tougourt. We cannot dwell upon all the places that were seen, and shall confine ourselves to a succinct account of the Tougourt excursion.

This excursion was organized with considerable difficulty, and the number of persons to take part in it had to be reduced to twenty. The details of it were studied with particular care by Mr. Jus, the well-known engineer, to whom the region to be traversed owes so much for the numerous wells that he has driven there. Mr. Jus was good enough in addition to oversee the material organization and assume the direction of the caravan.

The expedition would not have been possible had we not had the best of good will on the part of Generals Delebecque and Ritter, who accorded us their kind aid and gave favorable answers to the various requests that were addressed to them on the occasion.

The caravan started from Biskra on the 12th of April, the excursionists having since the 11th been assembled in this city, which they visited with interest. The oasis, old Biskra, the negro village, and the possessions of Mr. Landon were traversed in succession during a day that ended in a visit to an exhibition of dancing by the Ouled Naïls. It is useless to insist on the fact that a trip to Biskra, rendered very easy by the construction of the railway that ends there, and the operation of which will begin in a few days, will be the necessary complement of every sojourn in Algeria.

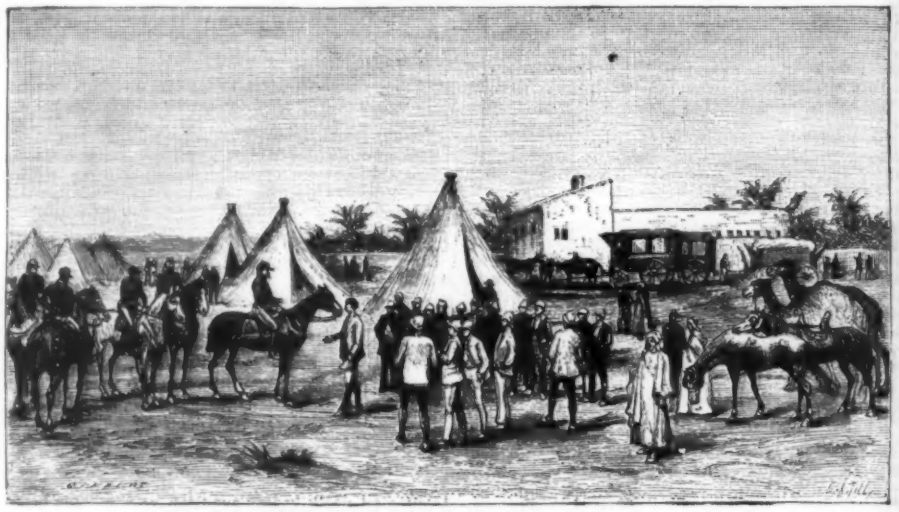


FIG. 1.—CAMP AND BORDJ OF CHEGGA.

Wednesday, April 12, at half-past five in the morning, all were assembled and got in place, and a start was made. Before summarily describing the trip that was about being made, let us offer a few remarks as to the circumstances under which it was effected.

Our caravan, composed of twenty persons, two of them ladies, and two servants, Ali and Saïd, was distributed through three ambulance wagons that had been kindly put at our disposal by the military authorities. Although these wagons were not very springy, and the road was often very full of ruts, the fatigue was not so great as might be supposed, this being doubtless due to the fact that there was plenty of room and that various positions could be taken. The wagons were drawn by four mules. Relays had been provided, so that the teams were changed every day at about noon. Finally, our artillery wagon, drawn likewise by four mules, carried our personal baggage, which had been reduced as much as possible, and the mattresses upon which we slept every night.

There had been sent in advance, to the way stations, the provisions for the day, consisting of various preserves, wine, Saint Galmier water, etc. The breakfast was carried in the wagons every day, and every evening, on arriving, the elements of the dinner were found. While the latter was preparing, the mattresses were put in place, and the flexible tables that were carried with the *materiel* were set. In the morning, the mattresses and baggage were put into the wagon, a cup of coffee was taken, and a start was made.

On the first day, this arrangement, to which we were not yet accustomed, put us back a little; yet, at half-

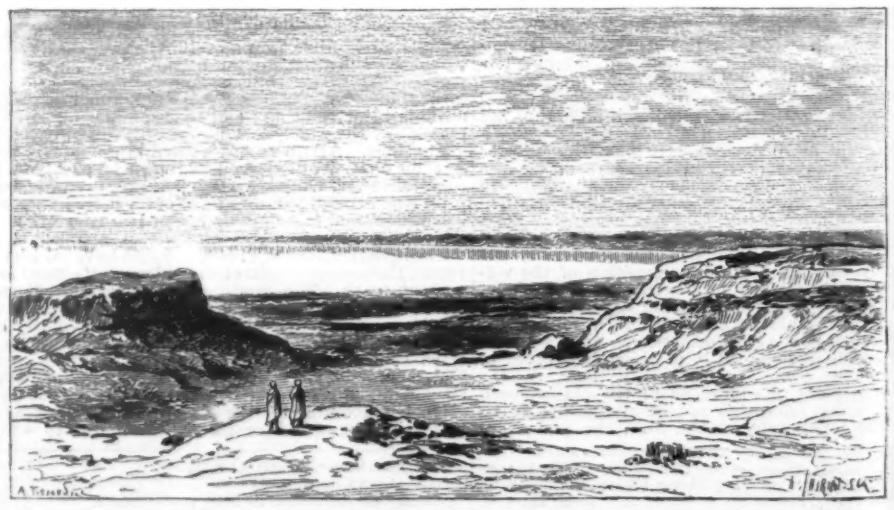


FIG. 2.—THE CHOTT OF MEL'RIR.

past six, the caravan got under motion, and, following the route that passes through old Biskra, soon reached the desert region, which was not so bare as we had imagined, but which here and there showed brushwood of a grayish green, the general appearance of which, however, viewed from afar, gave a sensation of verdure. The route followed was a wide track clearly traced by the passage of wagons and camels that had gone before, and the bed of which was now hard and full of ruts, now resistant and nearly even, and now consisting of a thick layer of sand that rendered the going difficult and laborious. At the start, we met or overtook groups of Arabs on foot or on muleback, and heavily loaded camels; but in measure as we got further from Biskra, the meetings were less frequent, yet without ever ceasing.

Here and there we saw a few rare birds and some rarer quadrupeds. In the horizon, a few oases appeared—Sidi, Okba, and Oumach—manifesting their existence by a long narrow band of somber color whose nature would scarcely have been guessed had not one been told of it beforehand.

We stopped for dinner at the *bordj* of Saada. A bordj is a square structure, usually exhibiting an interior court and erected near a well. The caravans stop at it to take a little rest. Often there are one or two entirely bare whitewashed rooms set apart for such Frenchmen as desire to pass the night in the bordj. Sometimes, and this is the case at Saada, the bordj may serve as a place of refuge for the inhabitants of the country in case of insurrection. It then has bastions, and the walls are pierced with barbacans.

The bordj of Saada is situated upon a small eminence not far from the bed of the Oued-Djeddi, which is now dry, but which, after the rainy season, extends over a considerable area and arrests communications, since the road crosses it.

Chegga, where we were to sleep, is an oasis of little importance, where there is a small bordj. This oasis occupies the bottom of a slight depression, and it was not until nearly reaching it that we observed it. What a picturesque spectacle! Around the bordj a true camp—tents, men, horses, mules, and camels (Fig. 1). Of these tents, some were intended for us, since the bordj was not roomy enough to receive us, and only the ladies slept in it. The other tents were those of neighboring tribes assembled for inspection by General Ritter, who received us most affably and made us visit his quarters. The caid, the son of Ben Gana, caid of Biskra, had erected for the general and himself two richly decorated tents.

The next morning, as we started, the camp broke. The general and his staff went off in a direction opposite to ours, while for a certain length of time the caid and his suite accompanied us, executing a true fantasia in our honor.

We breakfasted at Setil alongside of a well whose mouth seemed to be on a level with the surface, in the middle of the bed of the Oued-Itel, which was completely dry. The landscape, which was somewhat cheerless, was nevertheless animated by a view of the Aures Mountains, that were seen in the horizon tinged with varied colors, passing from rose to violet.

But we soon ceased to see them, and arrived at Kef-el-Dohor, where there is a tower in which is located an optical telegraph station. We were on the edge of a sort of cliff of great height, at the base of which begins the chott Mel'rir (Fig. 2.) It seemed absolutely as if we were in the presence of a lake. We distinguished the vegetation that appeared to cover the other margin, and the image of which was seen reflected by a sheet of water. But it was an illusion; there was no water, as we found out, for the route that we were following crossed the chott. The scarcely moist soil was covered with a saline efflorescence forming a white stratum which reflected the light, and the vegetation, which was far from being abundant, was reduced to small brushwood increased by an effect of mirage.

We dined and slept at Ourir in a bordj belonging to the Agricultural Society of Batna, which extended to us a warm and open hospitality in its buildings. We visited the wells, the plantations (some of which are old and others new), and the houses of the Khammes—the black natives connected with the exploitation. We likewise visited the neighboring oasis and the well that supplies it. The day ended with songs and dances (if the leapings and contortions that we witnessed may be so called) executed by the inhabitants of the neighboring oasis of Mraier.

FIG. 3.—OLD PALM TREES AND NEW PLANTATIONS, AT OURIR.

The bordj of Ourir, a large structure necessitated by the requirements of the well exploitation, is picturesquely situated in the vicinity of the tomb of a marabout and opposite some beautiful old palm trees (Fig. 3).

On the third day, dinner was taken at Nza-ben-Rzig, a bordj in ruins in a desolate place alongside of a well nearly filled in. A few hours afterward we visited a new well and witnessed the last boring operations. We dined and slept at the bordj of Sidi Yahia, where, as on the preceding evening, we were received by the Agricultural Society of Batna. This bordj is situated upon quite a high eminence overlooking the country. At a short distance away may be seen the bordj of Tala-em-Mouidi, belonging to Messrs. Fau & Foureau, and which we visited upon our return. A pond that was espied ended the promenade with some of the naturalists, who wished to examine it for little known animals.

The route that we took the next day for a certain extent followed the margin of a real lake which gave the landscape a cheerful aspect that contrasted with the preceding pictures.

We soon reached the oasis of Sidi Rached at the side of a bordj in a very bad condition. But sadder still was the aspect of the oasis itself, which was encroached upon by sand. Not only had the latter filled in the irrigating trenches, but formed real dunes in which the palm trees were buried to various depths (Fig. 4). These dunes are increasing every year, and are shifting. It has just been decided by the inhabitants to move to a short distance around a well that is to be driven.

FIG. 4.—OASIS OF SIDI RACHED.

The route that we were following was sandy and we made slow progress. Meanwhile, the summit of two towers was seen behind a dune—it was Tougourt.—*La Nature.*

TOBACCO CULTIVATION IN THE DUTCH EAST INDIES.

THE *Bulletin du Musée Commercial*, in an article upon the tobacco cultivation in the Dutch East Indies, says that the plant is cultivated in two different manners, according to whether it is intended for exportation or for local consumption. The home consumer prefers the long stalk leaf, and cares very little for the ground in which it is grown. When a plot of ground is chosen, either in or out of the *desa*, or village, it is sown after the weeds have been pulled up, and without being even dug up. If there does not happen to be sufficient natural shade for the young plants, they are covered with cocoa leaves. The end of the rainy season is the time usually chosen for sowing. In the morning or afternoon, seed mixed with sand or ashes is spread over the ground; it is then watered and covered with straw, in order to prevent the rains washing the seed away, and to keep the ground fresh in the middle of the day. The seed commences to sprout at the end of fifteen or twenty days. It is then necessary to guard against caterpillars, which have a preference for the shaded plants. At the end of fifty or sixty days, the planter for home consumption considers that the young plants are strong enough to transplant, and then commences to prepare the fields where the tobacco is to be cultivated. A preference is shown, as a rule, to the dry grounds, or *tégals*, as it is believed that tobacco cultivated in these is stronger than that grown in *sawahs*, or damp ground. Before taking the young plants from the nursery grounds they are well watered, and the strongest are first transplanted in rows about three feet apart. In this operation the farmer is assisted by his family, and it usually takes place in the afternoon. When the family is not large enough to assist in the work, friends and neighbors are called in to help him. A plantation seldom contains more than 3,000 plants. After planting, the young plants are again watered, and are protected from the rays of the sun by being covered with large leaves, chiefly those of the *djali*. During the dry weather they are watered every day until the plants have taken root, those which are weakly or dead are pulled up and are replaced by others, in addition the caterpillars are carefully removed. Occasionally the ground is weeded and broken up with a *patjol*, a species of mattock, great care being taken to heap up the soil around the stem. At the end of seventy days, the plants commence to bear buds; these are carefully removed with the fingers or with a small knife. After this operation, the shoots which spring from the stalk and injure the leaves are carefully watched. The highest leaf is considered by the growers as the best of the whole plant, and if it is desired to fully develop it the lower ones are sacrificed, so that in some cases only twelve or fifteen leaves are left on a plant, while those planters who only look to the quantity and not to the quality of their crop only remove from eighteen to twenty of the leaves three months after planting, and when the leaves begin to have a yellowish-green tint the gathering of the crop is commenced. This is done leaf by leaf, and great care is taken to keep separate the higher leaves, the lower leaves, and those growing midway; or again, these are mixed together in a certain proportion, according to the exigencies of the market for which the planter is growing. The crop is covered with leaves of the pisang, *Musa paradisiaca*, and placed upon bamboo tables. After the lapse of twenty-four hours, or when the leaves have become completely yellow, they are removed from the stems, and the principal ribs are taken away; a dozen leaves are rolled up in such a manner as to leave the largest on the outside, and they are then cut up very fine. This is a fatiguing operation, and requires much practice. The tobacco known under the name of "shag"—in Dutch *Apenhaar*—which is sold in European markets, shows to what a degree of perfection the natives have attained in the art of cutting up. The table used for this operation is a simple plank, long rather than broad, furnished with two ledges widened toward the top. The rolls of tobacco are placed between these two ledges, and are pushed forward by the hand as the knife cuts off the layers. The knife used is composed of a very long and broad blade in a short handle, and is used only for this purpose. When the planter's family is not sufficient for the cutting, friends and neighbors are called in to assist, and as a rule this assistance is not paid for in money, but the workpeople are well treated and receive a portion of the crop as their reward. For two or three days the tobacco which has been cut up is allowed to remain exposed to the sun, and during the night it is exposed to the air, as it is the opinion of the growers that the dew exercises a favorable effect upon the aroma and the color of the tobacco. As soon as the tobacco is dry and of a brown color, the layers are taken up and folded in two in the form of a square bundle. This operation is usually performed in the morning about nine o'clock, as then the tobacco is supposed to have got rid of the night dews, and has not become so dry as to be difficult to handle. The bundles so formed are wrapped up in banana leaves, and are then heaped up in bamboo baskets, covered in the inside with *pisang*, *djali*, and *alang-alang* leaves. In these baskets the tobacco is subject to a species of fermentation. When the tobacco is not intended for immediate consumption, it is kept in the baskets or in boxes, care being taken to exclude the air and light. The grower for the home market, who thus keeps his cut tobacco (*radjang*), provides himself with capital, for he knows that sooner or later Chinese, Arabs, or the native merchants will visit his village and purchase his surplus crop. Prices vary according to quality and circumstances, but native tobacco is always very choice, and assures to the grower considerable profit, if he is only careful in choosing his time for selling. Prices generally range from 20 to 80 francs per picul, the picul being equivalent to about 137 lb. avoirdupois. Native tobacco from some parts of the Archipelago, for instance that grown in Paraan, Kadoe, Redjang, or Palembang, has a very high reputation, and fetches a high price. It is the usual custom of the Javanese to plant his tobacco in the *sawahs*, or watered lands, after the rice harvest, and in the *tégals*, or dry grounds, after the maize harvest. It is believed that the dry ground

grows a stouter and more odoriferous leaf, and the irrigated lands a finer and larger leaf. The *Bulletin du Musée Commercial* states that the information respecting the tobacco industry in the Dutch East Indies has been furnished by the Belgian Consul-General at Batavia, who has also forwarded samples of the native products to the Commercial Museum at Brussels.

IMPROVED CHEMICAL APPARATUS.

By GEORGE H. BOSTOCK, F.C.S., etc.

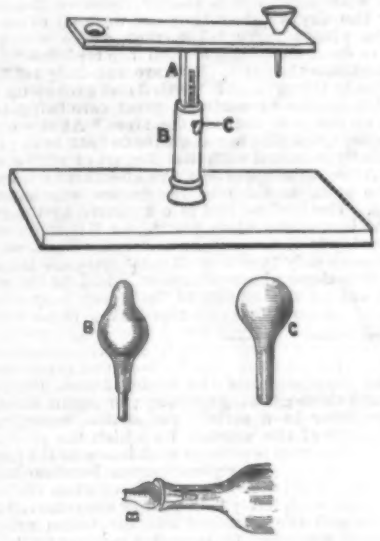
I HAVE devised an improved form of filter stand, in which the inconvenience arising from the projecting end of the rod, on which the support for funnel slides, is done away with. In this form I make use of the rod and socket arrangement. A glance at the accompanying sketch fully illustrates my meaning without further explanation.

A is the rod having funnel support affixed on its upper end; B is the hollow pillar into which A slides, being held firmly at any height by means of the screw at C.

Any ordinary joiner can make a filter stand after this pattern.

Having often been annoyed by the frequency with which the valve made of India rubber tubing—generally used when performing analyses by reduction, etc.—gets out of order and will not act, I was led to make use of a modification the nature of which is explained in a few words: instead of the piece of tubing with a slit in it I make a glass bulb, the size of which varies with that of the flask in use, and over this bulb I slip a small piece of India rubber tubing sufficient to cover the bulb completely. The shank of the bulb should be about 3 cm. long, and should be dropped into the neck of the flask, so that the globular portion rests on the top. When ebullition has entirely ceased, and the flame is removed from under the flask, the partial vacuum caused by the rapidly cooled gases inside draws the bulb tightly down on the flask neck, thus making a perfectly air-tight stopper, which requires considerable force to remove.

A is the neck of the flask; B is the bulb with its



covering of India rubber; and C is the bulb without its covering.

The principal merit of the contrivance is its simplicity and certainty of action.—*Chem. News.*

MANUFACTURE OF ALPHA-NAPHTHYLAMINE.

DR. OTTO N. WITT has recently described the methods used for successfully manufacturing this important base. It is essential that pure naphthalene be used, and a convenient charge consists of 250 kilo. mixed with 200 kilo. of nitric acid of 40° Be., 200 kilo. of sulphuric acid, and 600 kilo. of the acid used in a former nitration. The operation is performed in cast iron cylinders, fitted with a cooling jacket to prevent the temperature from rising above 50° C. After twelve hours, the contents are transferred to leaden vats to cool, the waste acid run off, and the product washed with water until it is no longer acid. The reduction is effected in plant similar to that used for preparing aniline from nitrobenzene, iron borings and hydrochloric acid being the reducing agent employed. The temperature in this operation should not exceed 50° C. After about seven hours the reduction is complete, and milk of lime is added to the mixture. It is next distilled in a current of superheated steam, and the black oil is subsequently rectified in wrought iron stills. Naphthylamine prepared in this way is a colorless oil, solidifying to nearly white crystalline cakes, containing no β-naphthylamine, but small quantities of another base which is probably paranaphthylene-diamine. α-naphthylamine has been used for some time in the manufacture of "martius" or Manchester yellow, which is a salt of dinitro-(α)-naphthol, and is obtained from α-naphthylamine by the action of nitric acid. The sulphonate of this salt is obtained by the Schollkopf Aniline and Chemical Company from α-naphthol-disulphonic acid by the action of nitric acid, and is known under the name of brilliant yellow. α-naphthol sulphonates are also used for the preparation of Tropæolin 0000 and scarlet G, which are azo colors obtained from them by means of the diazo compounds of aniline. When toluidine is substituted for the aniline, cochineal scarlet 2R is produced, and with xylidine the dyes formed are called azococcin 2R and cochineal scarlet 4R. Naphthylamine is also used for other dyes which are not at present the subject of any patent, and the demand for it is gradually increasing. It forms with sulphanilic acid and nitrous acid a red coloration which affords a very delicate test for minute quantities of nitrites.—*Industries.*

HOW TO ADMINISTER GASEOUS ENEMATA.

WISHING to try the treatment of pulmonary diseases by means of gaseous enemata, the following appliance was used, on the suggestion of Dr. J. Clark Stewart:

An ordinary siphon bottle, charged with carbonic acid gas and water in the usual way; a pound bottle containing a sulphide in solution, closely corked, and having a long inlet and a short outlet tube, both of glass; a rubber tube attached to the siphon connecting it with the bottle containing the sulphide solution, and the tubing with the metal tip of an ordinary fountain syringe conveying the sulphureted hydrogen from this bottle, where it is generated, to the rectum. When ready for use the siphon is inverted—for in this position only the carbonic acid gas escapes—and the cock is opened slowly. It is very easy to regulate the supply of gas in this way. The advantages of this appliance are:

1. Cheapness, a thing always worthy of consideration in trying new methods. All the material required will not cost over one dollar, and any physician can put it in working order.

2. Convenience for manipulation, there being no delay in generating carbonic acid gas and preparing the ordinary gas bag. It also does away with the double-valved syringe bulb and its continuous manipulation.—*Dr. H. M. Bracken, in the Medical News.*

IT may interest microscopists to know that the zinc double salt of tetramethyldiamidodiphenylthienylcarbinol, otherwise thiophen green, is excellent for staining sections, especially as a contrast color to carmine. It is soluble in water, alcohol, and chloroform.

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